TELEPHONE ENGINEER

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OVER-SPECIALIZATION A DANGER

One of the topics which absorbed the attention of a conference of Bell System operating executives held early in the present summer was the subject of specialization. While none of the discussion has been published, the notes given out concerning the conference indicate that the officials of the Bell companies are alive to the dangers of over-specialization that exist in such a large organization.

Efficient operation under present day conditions requires a high degree of specialization especially under the functional plan of organization. The disadvantage of this specialization is its narrowing effect upon the outlook of the individual so that men of proper caliber for executive positions are not developed. That Bell officials are alive to the situation is evident from the fact that the topic is given place on the program of a conference of its highest operating officials.

It is ordinarily thought that the smaller company organizations afford opportunity of development of all-round telephone men to a greater degree than do the larger companies but even here there is something of the same danger. How many times have the smaller companies looked over their forces for some one for promotion to a minor executive position and found no one with outstanding qualifications. For example, a company needs a plant superintendent. The general manager looks over his men and finds shortcomings in each of them. Bill is a good line foreman but knows nothing of switchboard or telephone equipment. John is a good switchboard man but he does not fit in with the rougher type of men that do the outside work. Joe is a good troubleman but he has the viewpoint of a purely maintenance man who would build a plant that would never give physical trouble regardless of the economic conditions involved. The selection must be made and so the one showing the greatest promise is given the promotion in spite of his evident deficiencies.

We are not advised as to how the Bell executives propose to avoid the dangers but it seems to us that there are two factors: the individual and the opportunity for broadening his experience. Not every individual has the characteristics that make a good executive but when one is discovered who shows ability along this line, every opportunity should be given him to learn something of all the other departments of the business outside his special line. A broad-gauge management whether in a large or small company will assume that every one associated with that company is interested in every phase of its activity and will see to it that every one is given the chance to become acquainted with the work of all departments. Men with no aptitude for executive work will not respond but those who have ability along this line will give a speedy indication of their development and the problem of supply of future executives in a large measure will be solved.

THE UTILITY TAX BILLS KEEP ON GROWING

Much has been written about the disproportionate amount of taxes paid by public utilities, and yet the annual tax bill of these companies is steadily mounting. In a recent letter to stockholders of The Tri-State Telephone and Telegraph Co., Pres. G. W. Robinson points out that taxes during the first half of 1925 are 14.72% higher than for the corresponding quarter of 1924, which is typical of what is happening.

Many reasons are given for these increases and, owing to different methods of taxation in various states, no single set of reasons will apply universally. One of the more general causes is the large increase in expenditures by all classes of governing bodies, from the local school district to the federal government. There is no question that the ready market for tax-free securities and participation by states in federal aid projects on a 50-50 basis have been the cause of much extravagance in governmental expenditures.

There would be little cause for objection if these additional tax burdens were distributed equally but, too frequently this is not done. In middle western states where a large proportion of taxable wealth is in farm lands, each successive revaluation during the last five years has shown a reduction. Other classes of property, particularly utility properties, have not shared this reduction; consequently, the burden has been shifted gradually so that the

taxes on utility properties steadily have risen.

It is argued that the public utilities pass on the increase to their customers and that, in the end, the same public pays the bill. While there is a measure of truth in this, the adjustment can not be made every time there is an increase in the amount to be paid. The utility must absorb the increase and frequently must carry it for a period of years before its next rate adjustment.

Many times when a rate increase is granted it is followed immediately by an increase in property valuation and a consequent increase in taxes so that part of the additional revenue immediately is absorbed. Unless allowance is made in estimated expense for this increase it is not the public but the stockholders who pay the bill.

No one seems to be able to point out the way of reduction of taxes for local and state purposes; so the only remedy for the utility would seem to be the inclusion of a proper allowance in estimated expense in all rate cases to take care of the increase that is almost certain to come.

RADIO OUT OF THE EXPERIMENTAL STAGE

Dr. Lee DeForest is quoted as having said that the radio art now is out of the experimental stage and today is progressing toward the status of a stabilized industry. Coming from a man who has been so intimately connected with the development of the art as Dr. DeForest, this statement must be given much weight.

Radio now has passed the first quarter-century of its life and the trend of future development should be pretty well established. In age, its status is comparable to that of the telephone in the year 1902. In 1902, the telephone had arrived and its place in the business and social life of the country was well established. It is true that many of the developments of the years since then yet were unforeseen, but there was no further doubt as to its place in the communication art.

We may, well, believe that this is the present state of radio. All of the progress that will take place in the next twenty-five years can not be predicted. Undoubtedly, there will be changes and improvements in the systems of radio communication and there will be extensions to the use of radio but its place now is pretty well determined as a means for broadcast communication, as distinguished from point-to-point communication on land, and as an extension of wire communication to moving objects on land and sea and in the air and to points that now are and, in the future, will be inaccessible to wire and cable lines.

MAKE YOUR CONVENTION PLANS EARLY

The dates for the annual convention of the United States Independent Telephone Association have been set for Oct. 13-16. It is not too early to begin making plans for attendance, and every telephone man should start to get his work in such order that he may be on hand when this convention opens, staying until the last session has adjourned.

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WHEN WILL WE BE ABLE TO TALK TO SAN FRANCISCO?

In a recent number of "Long Lines," Director F. A. Stevenson of the Long Lines Department of the A. T. and T. Co. tells of an otherwise well informed business man who recently asked: "When are you going to be able to talk from New York to San Francisco?" Strange as it may seem, there are many people who do not know that this service has been given for a decade or more.

Mr. Stevenson then goes on to point out that a vast majority of people do not appreciate the possibilities of communication over long distances and take advantage of them but rarely. The same condition will be found in every community. Few business houses are making as full use of the long distance service as would be of advantage to their business.

Three reasons are given to explain the attitude of mind of the subscriber: The cost is too great; It is too complicated a process to file long distance calls; The service is too slow.

It is probable that the latter two are greater deterrents than the first because it can be shown that where they have been overcome, the user finds that the benefits of the service make the cost a secondary consideration.

There is meat for thought in this for local exchange people. One source of additional revenue for the local exchange is increased use of long distance service. If the service is brought up to the proper place as regards convenience and speed of operation, well directed effort on the part of commercial representatives can do much to educate people to the use of long distance service so that, as Mr. Stevenson says, at the close of his article, "this service will become almost a national habit comparable with the use of exchange service today."

Testing Methods in Telephony

Fault Location and Measurement Methods and Instruments Simply Explained—The Wheatstone Bridge Simplified—Galvanometer Operation and Employment Is Explained

By P. Kerr Higgins

In discussing subject of testing method the author realizes not only the importance, but also the extent of the field covered and because of this it becomes a difficult matter to condense the valuable material available so that only the very necessary and best elements may be considered. Of these various essentials of economic management the intelligent location of defects and waste of material is a division requiring much study and attention at this time. During the past few years telephone companies, compelled by circumstances, have given considerable attention to organization, economic management and the saving of waste material. This is particularly true with regard to the larger companies and in a lesser degree true in regard to the smaller companies, although here the "hit and miss" method is still very much in vogue. It is hoped, however, that the articles on testing and locating defects may be of service not only to the smaller company but also to the larger company. In the case of the smaller company delicate and expensive instruments are not always available, but even if the special equipment or instruments now on the market are used for locating trouble, it is essential that at least a working knowledge be had of the theory upon which most testing instruments are built.

The fundamentals of testing in telephony, in general, come under three heads: One, impedance; two, pressure, and three, supply. If any two of these are known, the third can be measured by rules covering the requirements of each case. All conductors offer more or less opposition to the passage or flow of electricity. By regulating the pressure, we control the supply. A working knowledge of these facts and the rules governing them enable us to solve many difficulties in the everyday life of the telephone man.

Impedance is anything that will resist, oppose or hold back the flow of current and its effect is noticeable in several ways. One common effect occurs when current passes through a small wire and meeting resistance to its flow heats the wire perceptibly. Another effect is shown if iron filings or a magnetic needle be brought near such a wire, while the current is passing. It will be noted that a field of force or a magnetic field surrounds the wire. The heating effect indicates loss of energy and is due to the resistance of the wire which can be proven by replacing the small wire with one of larger diameter. If we double the diameter (four times the area) the wire will carry four times the amount of current, whereas if we extend the line (make it longer) the resistance is directly proportional to the length. The unit of resistance is the ohm, named after Dr. Ohm of Nuremberg, Germany, who discovered the famous law which bears his name. The magnetic effect referred to above forms the basic principle of all galvanometers used in testing. Electrical pressure is known as electromotive force and frequently abbreviated to EMF. Resistance is indicated by R. Current or the flow of electricity is indicated by C. The unit of EMF. is the volt, that of resistance the ohm, and of current the ampere. EMF. is the difference in potential between two points in a circuit. Current is the strength or quantity of electricity passing any part of a circuit in one second of time, and in direct current circuits varies directly as the EMF, and inversely as the resistance of the circuit. Electricity is frequently considered as analogous to a stream of water in a pipe. Hence, if one volt is applied to a circuit having a resistance of one ohm we say one ampere is flowing. In the case of water, flow is expressed in gallons per second. For example gallons per second equal pressure of water divided by resistance of pipe or in analogous electrical terms amperes equal EMF. divided by R. It is hardly necessary to amplify this matter further, as the Ohm's law and its application was fully discussed in Telephone Engineer of August, 1923, Vol. 27, No. 8, and September, 1923, Vol. 27, No. 9.

Some Facts About Fault Location

Fault location, as the term indicates, is a quantitative test; that is to say, the test not only demonstrates that there is a fault, but also indicates the precise point on the circuit at which the fault is located. The simplest test set is a strong magneto generator which will ring a bell through a high resistance of, say, from 25,000 to 75,000 ohms. When such a test set is used the bell and generator is mounted in a small portable case together with a telephone receiver which also may be used as a magnetic transmitter. In some cases a simple galvanometer or volt meter is added to the set. Such a combination is a test set in its simplest form and some of its uses are as follows: If a ground is suspected in a cable or an open wire the far end of the line is opened and the magneto and bell connected from the near end to ground in series with the line. The ringing of the bell indicates a closed or open circuit as the case may be. If the far end of the line has been opened, then the bell on the test set should not ring if the circuit is clear. If, however, the circuit is grounded, then the bell will ring, indicating trouble.

On long lines, however, there is always the possibility that the line and some other conductor in its neighborhood will form the two sides of a condenser whose capacity is great enough to ring the bell. For this reason such a test set on long lines except in the hands of an experienced man may be of very little value. On short lines where this capacity condition does not exist, this test set will indicate that trouble exists, but will not indicate its location.

On long lines a direct current is more serviceable than the alternating current of the magneto generator. In such a case a galvanometer or volt meter and battery is substituted for the generator and bell. In such a case the permanent deflection of the galvanometer needle indicates a permanent ground or leakage according to the deflection. An idea of the resistance of the fault may be obtained from the deflection.

Capacity on the line is indicated by a momentary deflection of the needle and its sudden return to zero. In making volt-meter tests care must be taken not to use too much battery power as this would have a tendency to heal up the trouble or dry out the moisture. Hence it is important that the minimum battery necessary be used. To test for a cross between two or more wires, one of the suspected lines is connected to the testing set and the other terminal of the test set to the line with which it is supposed to be crossed. The permanent deflection of the needle will indicate a partial or complete cross in a similar manner to a test on a grounded line. If the lines are clear the needle will remain normal or indicate capacity only. In all such tests one must be careful to see that the distant ends of

the circuits being tested are open and clear. Testing for bad joints on lines has already been discussed in TELEPHONE ENGINEER, *February*, 1924, Vol. 28, No. 2.

Another simple test may be made with a head receiver and three cells of battery. The connections are made in a similar manner to the others except that the wire from the receiver is not fastened to the end of the line under test, but touched at frequent intervals. The first touch will naturally produce a click in the head receiver due to the capacity of the line; subsequent touches should produce no click. If, however, after the first touch, clicks in the receiver are heard, this would indicate a cross or ground as the case may be. If the clicks are faint this would indicate leakage or moisture. Tests for open lines are made by grounding (single line) or short circuiting (metallic) the distant ends of the circuits under tests. Clicks received in this case would indicate continuity of the circuit, while if no click is received, the circuit would be broken. We are now ready to discuss some of the more delicate instruments used in testing, of which the Wheatstone bridge is perhaps the basic unit.

Wheatstone Bridge Simplified

(Author's Note—I have noted in conversation with a large number of wire chiefs and others who use the Wheatstone Bridge that their methods are more according to "rule of thumb" than otherwise and that few bridges now in use are used up to their full possibilities for no other reason than that many of our practical telephone men are deathly afraid of anything introducing mathematics. It will be my object in this short article to eliminate insofar as possible complicated formulas and yet explain the details of the Wheatstone Bridge in a manner readily understood by those having a limited knowledge of such matters and confine myself, as far as possible to simple arithmetic, using working examples.

These "Bridges" are made up in many complicated forms, some having the "Murray Loop" test added. It is not the intention of the writer to consider, at this time, these complex machines, but a simple ordinary type suitable for every-day use yet capable of accurate and wide range work. In order to follow closely the explanations it would very materially assist the reader if he could have a simple "Bridge" outfit before him while reading this article.)

The quantitative testing of telephone lines to determine the exact location of the trouble depends upon the use of the Wheatstone bridge principle, upon the fall of potential principle or upon direct galvanometer measurements. For resistance measurements upon which depends the location of crosses or grounds, the Wheatstone bridge is very convenient. This is made up of a kite-shaped arrangement of resistance in which the arms of the kite or bridge have different resistances. In the instrument are arranged two resistances in multiple, connected across (bridged) by a galvanometer or some other delicate instrument capable of indicating the existence of certain conditions. The condition most often used, that of zero deflection of the galvanometer, can only exist when the resistances bear a certain numerical relationship to each other. This relationship is very simple and usually is expressed by the following formula: A:B as R:X when A, B, R and X represent the four resistances shown in Fig. 1.

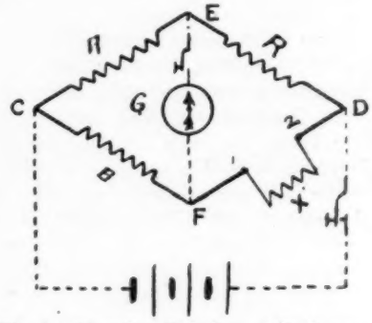


Fig. 1—Showing Relation of Resistances.

When the ratio of A to B is the same as R to X no current will pass through the galvanometer and a balance is said to exist.

In making tests, using the Wheatstone bridge (say for the measurement of resistance) the following method is used: A and B are adjusted to a definite ratio, for example 1:2, 1:10 or 10:1000, etc. The bridge arm is then manipulated until a balance is obtained, i. e., until there is no movement of the galvanometer. The bridge now expresses the ratio of A:B:: R:X. In such a test the bridge arm, X, is the unknown resistance and of course is determined by balancing the bridge by inserting in the arm X the resistance or line under test and when the correct ratio is established by varying R, the process is completed. So long as the galvanometer is across the exact electrical center of the circuit, that is, so long as the resistances on both sides of it are equal, the galvanometer needle will point to zero. By inserting or connecting an unknown resistance on the "X" side of the bridge, we can adjust the known resistance in the "R" side until we read zero. The unknown and the known resistances will then be equal if the A and B arms or equal will be in the same ratio as the A and B arms of the latter are unequal.

A More Complete Explanation of the Bridge

To explain the principle of the bridge more fully, it may be pointed out that the current from the battery is made to branch into two paths at C, Fig. 1, and reunite at D so that part of the current flows through each of the points E and F. A, B, X and R are known as the arms of the bridge, A and B being known as the bridge or ratio arms, R as the rheostat or adjustable resistance and X the unknown resistance. If the galvanometer shows no deflection, then it is apparent that the two points E and F are equal in potential since current can only flow as a result of potential difference. The bridge is then said to be balanced and the resistances in the arms will then have the relation to each other as expressed in the simple proportion given above:

$$\frac{A}{B} = \frac{X}{R} \text{ or } A \times R = B \times X$$

It is evident from the above simple proportions that if we know the values of three arms of the bridge the fourth can be quickly ascertained from the following formula:

$$X = \frac{A}{B} R$$

The resistances in the galvanometer or battery circuits do not affect the values or ratios of the bridge arms. The position of the galvanometer and battery may be interchanged without affecting the law applying to the bridge.

If the ratio arms A and B are equal the bridge has only a limited range of measurement. It is also evident that the adjustable resistance (R) will represent the total amount of the unknown resistance that can be measured with equal bridge arms. By changing the ratio of the arms of the bridge we are enabled to measure very high or very low resistances. This is done in the actual bridge by placing in the arms A and B resistances having values of at least 1, 10, 100, 1000 and in some cases 10,000 ohms. If the unknown resistance is equal to the ratio $\frac{A}{B}$ multiplied by the resistance in the rheostat to balance, it is evident that when measuring small resistances the greatest accuracy will be obtained by making A small and B large, as this will mean a division for the value of the rheostat. If for example A equals one ohm, B equals 1000 ohms and R equals 67 ohms, the unknown resistance would be .067. If we were measuring a large resistance we would then give A a large value and B a small value; for example, if A equaled 1000 ohms and B equaled one ohm and R equaled 67 ohms, the unknown resistance would be 67,000 ohms. From this may be deduced the two following rules:

Rule for Lesser Measurement—Divide the larger bridge arm by the lesser and

divide R by the quotient. Example A = 100, B = 10, R = 4, $\frac{100}{10} = 10$, $\frac{4}{10} = .4$ ohms, which is less than any one coil in rheostat.

Rule for Greater Measurement—Divide the larger bridge arm by the lesser and multiply R by the quotient. Example: A = 100, B = 1000, R = 7400, then $\frac{1000}{100} = 10$, $7400 \times 10 = 74{,}000$ ohms, or more than all the coils in rheostat.

In modern bridges the ratio arms are so arranged as to be interchangeable, Fig. 2, thus insuring a larger ratio. With the

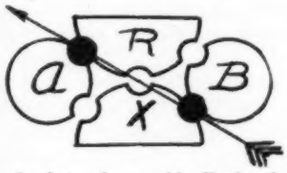


Fig. 2—Interchangeable Ratio Arms.

equipment and forming a part of it are furnished a battery and two keys as indicated in Fig. 1, one key being used for cutting in and out the galvanometer and the other key for cutting in and out the battery. The battery may be made an integral part of the equipment or it may be entirely separate as circumstances dictate. The coils (attached to brass blocks or mountings) are arranged in rows, from 0 to 10 in units, tens, hundreds and thousands and so arranged as to be available in series, in multiples or a combination of both of these by means of plugs or switches. The galvanometer also may form a part of the equipment or it may be separate.

The term "Portable Testing Set" is understood to mean a compact form of Wheatstone bridge complete with galvanometer and battery, mounted in a car-

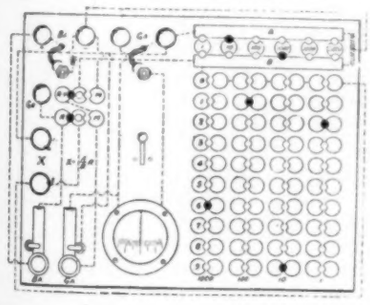


Fig. 3—Circuits of Decade Type Bridge.

rying case and arranged for the various tests to which the bridge can be put. Two common types are in use, namely the plug type (Fig. 4) and the dial type (Fig. 8). In the plug type the resistances are inserted in the circuit by manipulating plugs, while in the dial type switches or dials are used. From the general appearance of the complete portable set, one cannot see the geometrical forms as indicated in the diagram. However, an examination of the circuit will reveal the same theoretical arrangement.

How the Bridge Is Used

The use of the bridge is quite simple. The resistance to be measured is connected between the posts marked X, Fig. 3, and after setting the plugs or switches for measuring resistance as distinguished from fault location, and as given in the

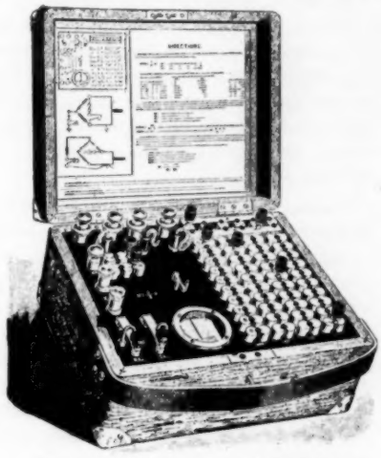


Fig. 4—Plug Type of Bridge.

directions for using this particular instrument, the rheostat is adjusted until a balance is obtained as indicated by no deflection on the galvanometer. The proper values in the bridge arms to be used to get the best results for any measurement are shown in a table and set of instructions which accompany the instrument.

There are several very fine makes of Wheatstone bridges on the market, all of which are reliable, accurate and simple in design.

The coils of the bridge are wound from fine German silver or other resistance wire of a given standard, non-inductive resistance. This non-inductive effect is obtained by doubling up the wire and winding it on a spool in loop formation, or it may be made in loose coils. No metal should be used in their construction. They are usually covered with paraffine wax, the ends of the coils terminating in brass blocks (in the plug type bridge) and separated by an air space in which a plug is fitted when the coil is cut out of use. When a particular coil is to be used, the plug is taken out, which removes a short circuit from the coil, thus calling it into service while all the others are plugged up.

In making tests, it is extremely important that the smallest amount of battery necessary should be used so as not to overheat the resistance coils, thereby changing their resistance and perhaps burning them up. When low resistances are being measured, a battery of only a few volts is necessary and the voltage is increased very gradually as the resistance to be measured is increased. A commutator plug or other switching device for varying the voltage for, say, from one cell to twenty-five cells or fifty cells in extreme cases is very convenient. Modern bridges are equipped with batteries and such an arrangement contained in the same box with the bridge.

The operation of the galvanometer needle to the left or right if carefully noted and studied will be of great assistance to the tester in determining whether to raise or lower the resistance in R to

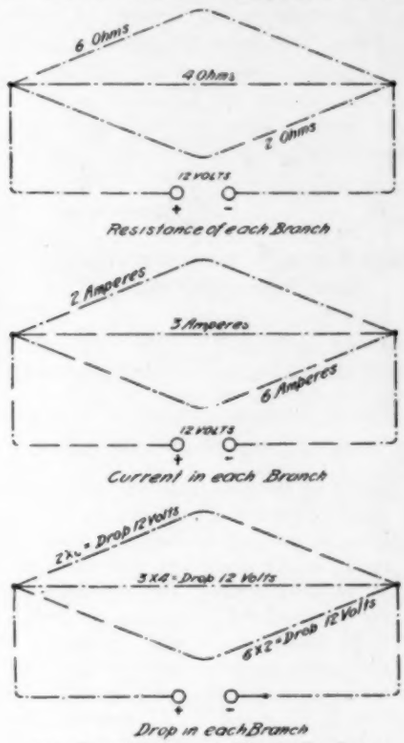


Fig. 5—Diagram of Kirchoff's Law.

obtain a balance. In order to familiarize one's self with the arrangement of the bridge in one's possession, it will be necessary to pull out all the plugs and test out the connections with the battery and buzzer or receiver, then draw a theoretical diagram as in Fig. 1. In this way you will at once familiarize yourself with the proper connections of all the wires.

Accurate measurements depend on having the proper resistance in each of the bridge arms. Hence the following table may be found useful in arranging the plugs.

Resistance to be measured.	A Arm.	B Arm.
Below 1.5	1,000	1
Between 1.5 and 10	100	1
Between 10 and 75	100	10
Between 75 and 1,000	1,000	100
Between 1,000 and 6,000	100	100
Between 110,000 and 1,110,000	10	1,000
Between 1,110,000 and 1,111,000	1	1,000

According to Kirchoff's Law the total

resistance of any number of resistances in multiple can be readily calculated. Not only is the resistance estimated, but the current in each branch, and consequently the drop of potential is readily calculated. This is shown in diagramatical form in Fig. 5. In these diagrams the resistance and current are given. Consequently the drop in each branch is twelve volts respectively; that is to say, the application of twelve volts to a resistance of 2, 4 and 6 ohms would mean a current of 6, 3 and 2 amperes and a drop in potential in each circuit of twelve volts. Such being the case, the investi-

Fig. 6—Resistance Values of Respective Arms.

gation of the conditions that exist in the circuit composed of resistances forming loops in multiple is similar in many respects to the conditions that exist in a Wheatstone bridge. The explanation of the effect of this interesting condition is to be found in a careful examinaion of the various drops occurring in the different parts of the circuit designated in Fig. 6 at A, B, R and X. If we give values to the resistances comprising the respective arms of the Wheatstone bridge as shown in Fig. 6, the following conditions exist:

Arm A Drop 50 ohms × ½ amp. = 25 volts
Arm B Drop 100 ohms × ¼ amp. = 25 volts
Arm R Drop 150 ohms × ½ amp. = 75 volts
Arm X Drop 300 ohms × ¼ amp. = 75 volts

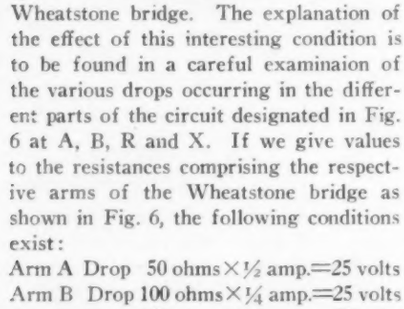


Fig. 7—Wheatstone Bridge of Incandescent Lamps.

In other words an examination of the theory and practice of the Wheatstone bridge is simply an examination of the principles underlying the theory and practice of electric wiring. In the illustrations it is shown that the points to which the galvanometer is connected are those at which the drop is equal. Hence it follows that these are the only points in the circuit at which the galvanometer will remain at rest. An instructive experiment is that of constructing a Wheatstone bridge of incandescent lamps as shown in Fig. 7 and noting the fact that when the lamps in the four arms are burning, the middle lamp will not burn. The entire situation can therefore be summed up in a word, namely, that the drop must be equal in the A and B arms and the indicator or galvanometer will be at rest and in order to secure this condition of affairs, the resistances of the different arms must express the ratio of A:B as R:X.

Having mastered the rudiments of the bridge as given, it will be much easier to take up and understand the more complicated work of locating open wires, grounded lines and crosses. In order to make definite accurate tests for the location of such trouble, it is important that cable and line records be correct and that you have, or make up, data showing the resistances of your lines and cables under normal conditions. These data may usually be had at the time of the test, but is a very great help if they are already in your possession, thus making a considerable saving of time, which is frequently a very valuable feature when a line or cable is out of order. Upon the accuracy of this data will depend the correctness of your fault location. The accuracy of the bridge measurement itself is indicated in the following table.

Resistance.	Probable accuracy of measurement. Grade B.	Grade A.
.01 ohm	2%	2%
.1 ohm to 50,000 ohms.	¼ of 1%	⅛ of 1%
100,000 ohms.....	¼ of 1%	⅛ of 1%
1,000,000 ohms.....	2%	2%

The theoretical range of the average set is from .001 ohm to 11,110,000 ohms, and measurements can be made throughout this range; however, below .01 ohm or above 1,000,000 ohms, the accuracy falls off rapidly.

Galvanometers

Just a few words in respect to galvanometers, of which there are many types, but practically all built on the basic principle of the magnetic needle. Fundamentally, a galvanometer is an instrument for measuring electric currents. Its operation depends on the action of a magnetic needle suspended in or between a coil or coils of wire. If a current is sent through such a coil, the needle will be deflected, the deflection being proportional to the current flowing. The galvanometer is usually used in telephone testing as an indicator of the presence of the current especially in conjunction with the Wheatstone bridge for measuring resistances. It indicates not only the presence of the current, but also its direction. If magnitude of the current is to be determined, it is necessary that the instrument be properly calibrated, and this is done by comparison with a known standard. In order that the galvanometer may be as sensitive as possible, the needle should be as light and small as practical, to insure an easy movement. The earth's magnetism is strong enough to affect such a needle and hence it should be protected by means of another magnet or be placed in a closed magnetic field.

Probably the simplest form of galvanometer is that of the magnetic needle itself properly suspended. If now a wire in which current is flowing is held parallel with this magnetic needle, it will be deflected and tend to set itself at right angles to the wire. This needle may be furnished with a pointer and so arranged as to pass over a scale divided off into degrees. It is apparent that the movement of such a needle under influence can be measured. In order to increase this effect, make up a small bobbin and on it wind some wire, leaving a space inside the spool for the location of and free movement of the magnet. The pointer must extend beyond the spool so as to move freely over the scale. By such an arrangement the effect of the current is very much multiplied. Such a galvanometer will fill all the requirements of ordinary testing and can be made up in neat form and enclosed in a glass cover with suitable terminals for connecting the outside terminals to the galvanometer coil. The readings on such an instrument will be proportional to the resistance in the circuit. The sensitiveness of a galvanometer may be defined as the current and amperes required to give a unit deflec-

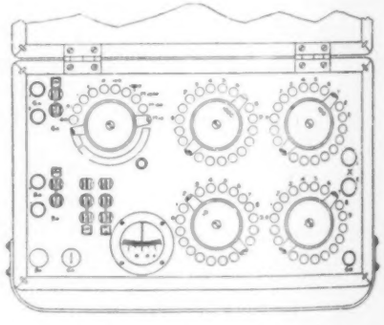


Fig. 8—Diagram of Dial Set.

tion, or as the resistance of a circuit containing the galvanometer in which one volt will give one degree on the scale, with the galvanometer scale one meter distant from the mirror or needle. Galvanometers may be arranged for what are known as zero deflections and for direct deflections. The former type is used for low resistance testing and in conjunction with the Wheatstone bridge; the latter type is used only in the testing of high

resistances such as insulation, etc. The coil used in the former usually has a resistance of about four hundred ohms, while the coil for the latter has a resistance of about 3500 ohms. These coils are usually mounted on separate tubes for convenience The use of the mirror type galvanometer is considered by many as necessary in making capacity tests. The mirror used may be either plain or concave, the former being usually preferred and used with a telescope and scales; with the latter a lamp and lens and scale are sometimes necessary.

For exact measurement of insulation and capacity, sensitive instruments are needed and the mere uncalculated action of a current and a magnet will not suffice. The types of galvanometers most frequently used in quantitative work are the Thompson and the d'Arsonval.

The Thompson galvanometer, while made in a number of different forms consists, in principle, of a number of minute permanent magnets attached to the back of a small round mirror which is suspended inside of a coil of fine wire by an almost invisible fibre of silk or quartz. A ray of light is directed on to the surface of the mirror, and the beam of light reflected from it plays upon a graduated scale. It is exceedingly sensitive—too sensitive, in fact—to outside disturbances to make a satisfactory portable instrument. It is therefore used mostly in laboratory work, the d'Arsonval type being preferable for portable work.

The d'Arsonval galvanometer reverses the arrangement of the Thompson, comprising a suspended coil in the field of a powerful permanent magnet. A small mirror is fastened to the coil. The mirror is used because it allows the use of a beam of light for an indicator; and as the light ray has no weight or inertia, the indicator may be as long as the desired sensitiveness of the instrument demands.

A ray of light was mentioned as forming the indicating needle on both types of galvanometer. A more convenient method, however, is to mount a small telescope just above the scale so that on looking through the telescope the scale is seen reflected in the small mirror on the needle or coil of the galvanometer. It is obvious that as the mirror turns, the reflected scale will travel to the right or left, as the case may be.

Galvanometers such as those just described are very sensitive and sometimes the current being measured is strong enough to turn the indicator clear beyond the scale. In this case a known resistance, called a shunt, is bridged across the terminals of the galvanometer, so that only a definite and known portion of the current passes through the instrument. This ratio being known, the total current is readily calculated. For example, a shunt having one-ninth the resistance of the galvanometer would take nine times as much current, or nine-tenths of all the current. The galvanometer would therefore be one-tenth of the total current.

The deflection on the scale of a reflecting galvanometer is practically proportional to the amount of current flowing, and so inversely proportional to the total resistance of the circuit. When the EMF. (voltage) is known, the deflections obtained through known and unknown resistances are inversely proportional to the resistances. It is customary to work out a standard or working constant by reading the deflection with a known resistance and then calculating the hypothetical deflection through a resistance of one megohm. All other deflections in measuring resistances are compared to this constant.

Merge Eight North Texas Independents

Sherman, Tex.—C. A. Shock as vice-president and general manager is the active head of the Northern Texas Telephone Company, which is to make Sherman its headquarters. Telephone properties at Bonham, Denton, Pilot Point, Tioga, Collinsville, Whitesboro, Sherman and Howe are owned and operated by the Northern Texas.

The Northern Texas Telephone Co. was incorporated in the latter part of 1924, with headquarters at Sherman.

The official family of the Northern Texas Telephone Company, J. B. Earle, Waco, president; C. A. Shock, Sherman, vice-president and general manager; J. G. Crane, Kansas City, vice-president; E. C. Blomeyer, Kansas City, vice-president; V. E. Chaney, Kansas City, secretary; C. A. Bennett, Kansas City, treasurer; Mrs. C. W. Embry, Sherman, assistant treasurer; F. C. Dillard, Sherman, general attorney.

Hundred at Tyler, Texas, District Meeting

Tyler, Tex.—One hundred telephone men and women from northeast and east Texas attended the annual two-day district conference held under the auspices of the Texas Independent Telephone Association. R. B. Still outlined the purposes of the meeting and enumerated the reasons that make imperative the improvement of telephone service by Independent telephone operators.

George McQuaid of Dallas, director of the Texas Public Service Information Bureau, spoke on telephone service from the viewpoint of the public.

Secretary L. S. Gardner of the Texas Independent Telephone Association took up the subject of the relation of accounting to financing. Financing operations necessary for many Independent telephone concerns are made difficult, Gardner said, by improper accounting methods in use.

"Satisfying the Customer" was the subject of the final address on Wednesday's program, delivered by Sam H. Shutt of Waco, superintendent of Texas Long Distance Telephone Company.

Open discussion of varied operating problems closed the opening days' program. Thursday's program was devoted primarily to traffic problems.

Telechronometer Views Bright Future, Says Babcock

Seattle, Wash.—According to Garrison Babcock, moving spirit in the Telechronometer enterprise, the Telechronometer has emerged from the usual difficulties attendant upon the childhood of machines as well as mankind. The company now is undergoing reorganization and the re-adoption of its service in Everett seems probable in the near future. Foreign patents are being applied for. Dean Magnusson of the University of Washington College of Engineering, who was appointed by the state to pass on the Telechronometer, has given it unqualified endorsement.

London-Germany Telephoning Now Routine

London, England—Four weeks' experiments to establish telephone service between London and Frankfort-am-Main (Germany) resulted in success on August 7 when excellent communication was obtained via Cologne and Amsterdam.

Nashville, Tenn.—Headed by Ben S. Read sixty Southern Bell veterans attended the annual meeting of the Tennessee chapter of the Telephone Pioneers of America.

Arkansas Independent Sold to Reputed Bell Interests

Chicago, Ill.—Comack and Company, believed to be acting for the Southwestern Bell, have bought the Rice-Bell Telephone Company, Arkansas' largest Independent company. Price was $150,000, according to W. W. Brown, Camden, Ark., president of the Rice-Bell company.

The Electro-Magnetic Wave

An Historical Account and Non-Mathematical Explanation of the Character of Electro-Magnetic Wave Motion and Its Application to Communication Engineering

By K. W. WAGNER, PH. D.*

The history of the electromagnetic wave may logically be divided into two parts, namely the pre-Hertzian period and the post-Hertzian period. In the pre-Hertzian period two theories of electricity contended for superiority; one, the "action at a distance" theory, dealt with mechanical forces acting between electrically charged bodies, and between magnetic poles and electric currents, while the other, newer theory recognized the phenomena of electromagnetic induction discovered by Faraday.

Faraday, guided by his experiments, had conceived the electromagnetic field, which he lucidly represented by his tubes of force and the electromagnetic stresses acting therein; he never gave to his brilliant researches a mathematical vestment. Perhaps for this reason his contemporaries did not realize the depth of his thoughts as the trend of the times inclined strongly toward mathematical physics; the action at a distance theory, thanks to its mathematical elegance, had more fascination for the physicists of Faraday's time. It was left to Maxwell's mathematical genius to express Faraday's ideas by numerical equations which permitted to recognize, prove and utilize the relations of electromagnetic quantities embodied in the lines of force conception. Maxwell, by adding to Faraday's ideas the dielectric displacement current, completed the edifice of classical electrodynamics.

The most important conclusion that Maxwell drew from his electrodynamics was that electromagnetic fields propagated through space in the form of transverse waves with the velocity of light. He reached this conclusion mathematically by solving a differential equation. The gist of his calculation can be made clear in an elementary manner, which will reveal the kernel of the Faraday-Maxwell conceptions.

In Fig. 1, space is divided into two parts by a vertical plane, shown in cross-section by QQ. The part to the right of QQ is assumed not to contain a field, while the part to the left is the seat of a uniform electromagnetic field of a particular kind. Let the magnetic field lines, H, run vertically from top to bottom and the electric field lines, F, run horizontally from the rear to the front, then the relation between the intensity of the electric field and the intensity of the magnetic field may be expressed as $F = cH$, where c designates the velocity of light. By the following reasoning it may be shown that a distribution of the electromagnetic field, as shown in Fig. 1, cannot remain unchanged, but that the wave front represented by the plane QQ must inevitably move to the right with the velocity of light.

Imagine a very small horizontal strip (Fig. 2) placed so that its left edge just rests in the field and apply to this strip the law of induction. As one edge of the strip only is situated in the electric field, an electromotive force is produced circling around the strip's area. Its presence necessitates, according to the law of induction, a change in the magnetic flux which permeates the area of the strip. The initial flux is zero; a calculation would show that the magnetic flux increases with a certain velocity which corresponds exactly to a displacement of the separating plane, QQ, to the right with the velocity of light.

The same result is obtained for the electric field when placing a small strip vertically with its left edge into the magnetic field (Fig. 3). The dielectric displacement current for this strip is initially also equal to zero, but this state cannot remain because the magnetic tension around the strip is of a finite amount. The law of the magnetic circuit demands that the strip is permeated by a current having an intensity corresponding to the magnetic tension circling around the strip. Assuming the strip to be non-conducting, the current can only be a dielectric displacement current, that is, a change of the dielectric displacement flux permeating the strip area. In this case also a calculation would show that the velocity of increase of the electric flux corresponds to the velocity of light at which the separating plane, QQ, moves to the right.

The above discussed field distribution is the one of a plane electromagnetic wave and the reasoning shows that the mechanism of the wave propagation is constituted by the double linking of the magnetic field intensity with the electric field intensity which form the substance of the fundamental laws of the electromagnetic field.

Having proved to his mind theoretically the possibility of electromagnetic

**From an address by the author before the Hamburg University at the inauguration festival of the Heinrich Hertz Society. Translated by F. J. Dommerque.*

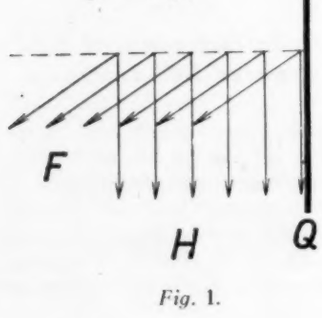


Fig. 1.

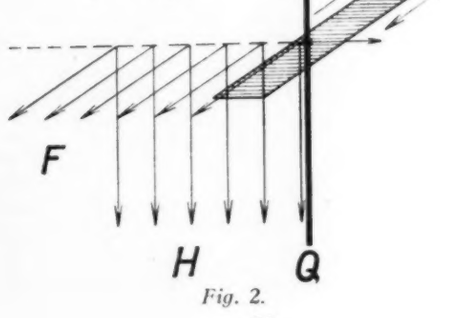


Fig. 2.

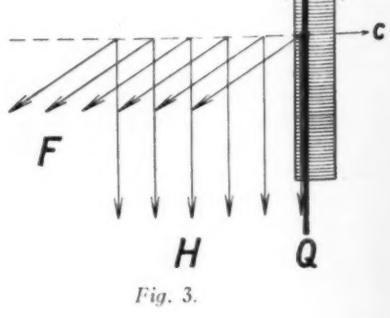


Fig. 3.

waves, Maxwell immediately surmised that the light rays were electromagnetic waves.

It is easily understood that Maxwell's theory did not find immediate recognition. The form given to it in his treatise on electricity and magnetism made its conception harder, even Heinrich Hertz acknowledges that he experienced difficulties when he first studied it.

Helmholtz soon recognized the importance of Maxwell's representation and asked the Berlin Academy of Sciences, in 1879, to offer a prize for a paper which would give evidence of electromagnetic induction effects of the dielectric displacement current in insulators. He also asked Hertz, his most able scholar, to try for the prize; but Hertz declined, having become convinced by calculations he made that the ways and means available at that time were insufficient to solve the problem. However, this episode had its good feature; it awakened in Hertz the ambition to find a solution in some other new way at a future date. Subsequently his now famous work in the period from 1886 to 1891 fully confirmed Maxwell's theory; he produced electromagnetic waves in free space by means of rapid electric oscillations. By ingeniously conceived experiments he could prove that these waves could be reflected, refracted and polarized the same as light waves.

Unfortunately, Hertz did not live to see the technical application of his discovery. A few years only had passed since his death when the young Italian, Marconi, succeeded, to telegraph without wires by means of Hertzian waves. This was the pioneer work in practical application, though signals could be sent over a few miles only. The work expanded under the efforts of scientists of all countries until wireless communication now bridges sea and land. One invention followed the other; first the coherer, then the crystal detector, the Poulsen arc, the high frequency machine, to mention only a few of the most important ones, and finally the electronic tube which generated, detected and amplified electric oscillations. Wireless news transmission has become an indispensable instrument of the present day; soon wireless transmission of pictures will be an everyday occurrence. The wireless telegraph assists the sea captain to ascertain the location of his vessel and guides him in unfavorable weather and adverse seas; the "S. O. S." signal calls for help in great danger.

The most admired and most general application of the electromagnetic wave is made in broadcasting. It is astonishing that just that property of the electromagnetic wave which had always been considered a disadvantage, namely its propagation in all directions so that everybody could hear the message, was put to the greatest service. One may ask why the electromagnetic wave was given over to other uses during fully twenty-five years before it was applied to the greatest spreader of communication imaginable. The answer is that only the electronic tube presented the technical apparatus to make broadcasting a commercial success.

In reality the satisfactory reproduction of speech and music is by no means a simple technical process. The musical notes of eight octaves, the difference in loudness from the finest pianissimo of a single musical instrument to the ponderous fortissimo of a full orchestra must be transformed into electric currents, which are impressed in the sender upon high frequency electric oscillations to be changed in the antenna into corresponding electromagnetic waves. In the receiving set the reverse takes place. The arriving electromagnetic wave excites in the antenna rapid vibrations; the vacuum tube or the detector transforms the rapid vibrations into ordinary low frequency currents which again are retransformed into sound vibrations in the telephone, or in the loud speaker after suitable amplification. These transformations have to take place without distortion, because the ear is very sensitive to the slightest changes in the tone structure. Considering, furthermore, that the public demands a simple and economical receiving set, it will easily be understood how much technical development was necessary before broadcasting could be accomplished.

In many occasions electromagnetic waves are conducted along wires. It can be shown that any electric flow in wires can be represented as wave motion. Thus the wire wave is as old as the propagation of electric currents over conductors. However, the first man to define clearly the phenomenon of electromagnetic waves, that is, of the propagation of the magnetic and electric field surrounding the wire in wave form, was Oliver Heaviside in his Electrical Papers (1892). Pupin, who invented the loading coil to reduce attenuation of current in the line, attributes his success to his habit of considering the electric actions in wires as wave phenomena. Since then in electrical engineering, wave resistance of a line, propagation constant and attenuation of a wire wave have become familiar conceptions.

A method of broadcasting is being developed which uses wire lines to direct the waves; sometimes this is called "wired radio." The difference between space radio and wired radio is that in the first one the electromagnetic waves are radiated into space, while in the latter the waves pass along the wire and are directed to the receiving set. Consequently, to broadcast over a given length of wire only a small fraction of the energy is required which would be necessary for broadcasting into space. For instance, to broadcast over an ordinary aerial telephone wire line 300 miles long one watt will be sufficient, while sending a wireless telephone message over the same distance would require from five to ten kilowatts.

The principle of broadcasting over wires has been applied to multiplex telephony, whereby as many as five telephone messages may be transmitted simultaneously over one and the same open wire line. To send telephone messages over high frequency carrier waves through cables is not feasible with the kind of telephone cables now in use, but they may be used for multiplex telegraphy, which requires only low frequency waves. There may be transmitted as many as ten telegrams simultaneously over one pair of cable conductors.

High tension transmission lines are being built to an ever greater extent. The high tension currents render speech over a telephone line on the same poles extremely difficult. As any high tension line is an excellent wave conductor, this line is particularly adapted for high frequency carrier wave telephony. Therefore many power transmission companies are sending telephone messages in the regular course of business over their high tension lines.

The technical application of the electromagnetic wave has already taken on great proportions but everywhere the inception of still greater development and expansion is recognizable.

Independents Prepare for Record Convention

Chicago, Ill.—Officials of the United States Independent Telephone Association are planning for one of the liveliest and most helpful conventions in annals of the association to be staged at Hotel Sherman, Chicago, October 13-16. Arrangements have been completed for taking excellent care of all visitors to the convention, under a room allotment plan.

General sessions will be held Tuesday afternoon and Wednesday and Friday mornings, Division meetings of the traffic, accounting and plant sections will be held Wednesday afternoon.

Thursday will be Pioneers' Day and a feature of the day's entertainment as provided by the Independent Pioneers' Telephone Association of the United States will be the luncheon and entertainment.

At noon Friday the state association executives will have a luncheon and discuss their mutual problems.

Arrangements have been made with the railroads for the granting of reduced fares, the usual one and one-third fare for the round trip on the certificate plan having been granted.

Building the Pole Line

An Article Written from a Different Viewpoint and One Deserving Careful Study. It Tells How the Work Is Done Rather Than What Is to Be Done

By JOHN M. WALSHE

To dig pole holes in ordinary soil, each man needs a spoon and a bar, also two or three shovels are required for size or light pole hole diggers.

Men who dig anchor holes will require a pick in place of a bar and a shovel instead of a spoon.

The pole hole diggers use the shovel to cut the sod and for a short distance down, so that the next man passing collects it as he passes to start his hole.

As the digger approaches the stake marking the place around which the next pole hole is to be dug, he should decide on which side the soil can most conveniently be placed. When the poles require very large holes the soil should be placed in two heaps, one on each side of the hole.

Soil from holes for smaller poles up to about forty feet long should be placed in one heap on the side next the road where possible. In any case the soil should not be put in a heap in line with the pole holes as that place should be occupied by the pole, the butt being right up to the hole.

When the digger arrives at the stake he must look at the marking to inform himself of the size of the hole.

Now, in staking (see July number, TELEPHONE ENGINEER, p. 21) it will be recalled the diameter of the hole was not marked on the stake, only the depth being given, as the diameter is the same for poles of the same class, so the diggers are given instructions to dig holes all the same diameter. In cases where it is possible to distribute the poles before the holes are dug, a small saving in digging is in some cases made by digging the hole to fit the pole, but it is also often a great advantage when the butts of the poles are irregular in size. The shovel is first used to cut the sod all around the stake at a distance which will leave the hole between five and six inches greater than the diameter of the pole at the butt. The hole must be sufficiently large for tampers to be used all round the pole right down to the bottom of the hole. As tampers are at least two inches wide, their free use requires this allowance.

When the use of the shovel has become inconvenient because of the depth of the hole, the bar is then used to cut down the sides of the hole and loosen the soil at the bottom, when the spoon is used to lift it out. This procedure is continued until the hole is finished, the bottom being left solid and flat all over.

The digging of pole and anchor holes is an expensive operation and one in which much time can be saved by studying the operation and eliminating unnecessary motions. A comparison between the movements of a day worker and a man paid by the foot is most instructive.

Framing the Pole

The framing of poles is preferably done in the pole yard before they are distributed along the line. The work can be done at any convenient time, however, it is usually found most convenient to have two or more operations going on at the same time and the men who are to erect the poles can be employed framing poles and assembling cross arms while the pole holes are being dug.

The tools required for framing poles should comprise the following:

1 rule, 2 ft., 4 fold
1 chisel, 2-in. socket
4 draw knives, 16-in.
1 cant hook
1 handsaw, 26-in., 12 points
1 brace
2 bits, 11/16 and 9/16-in.
1 crosscut saw, 6 ft.
1 saw file
2 pencils
1 steel square
1 axe
1 string, 50 ft.
2 awls

The number of each will depend on the number of men and their qualifications. The numbers given are for six men of whom only two are first class.

The operation of framing may be described as follows, when carried out in a pole yard.

Two poles are laid out on the ground at right angles to the pile of poles and at such a distance apart that the poles to be framed rest on them at a distance of about five feet from each end. For example the two poles of the runway would be fifteen feet apart for framing twenty-five-foot poles.

About twelve poles are now rolled on to the runway and the unskilled men are furnished with draw knives to shave such as are necessary.

The skilled men then roll over the poles farther from the stock, using the cant hook if necessary to find out which is the front and which side contains the belly. By looking along the pole as it is turned it is easy to decide which position presents the greatest bend. A line is then drawn across the top of the pole with the pencil in the same direction as the greatest bend in the pole.

If poles are nearly straight they may be turned by hand from the top. When the cant hook is used it should be used near the butt of the pole to avoid injury.

It is at this time that poles suitable to be cut up for anchors are selected. Poles which are abnormal in any way are usually used, the logs being cut in lengths as specified and distributed as required with the poles.

The line drawn across the top of the pole indicates the direction of the apex of the shed. If the cross section of the top of the pole is a circle this line should be a diameter passing through the center of the circle. If the cross section is oval or irregular, the line may bisect the area, but in any case must be in the same plane as the belly and should form a reasonable apex for the shed.

To cut the shed at an angle of forty-five degrees from the axis of the pole it is only necessary to remember that the cut will reach down half the diameter of the pole at the top. For example, the shed of a pole with an eight-inch top will extend four inches down the pole on each side.

The length of the cut is another matter and need not be considered if the angle is correct. If anyone wants to know, however, it is the square root of the quantity obtained by adding half the diameter squared to half the diameter squared.

The handsaw is next used to cut the shed. The handsaw is preferred as it leaves the surface in better condition for the edged tool used to finish.

The reason for providing a shed in this way is to prevent moisture entering the pole and causing rot, and, to some extent, to improve its appearance. Now this object will not be attained unless the wood is finished off quite smoothly, therefore the saw is followed by the chisel or draw-knife—whichever is used must be very sharp. The best results are obtained with a chisel. The writer has seen quite satisfactory sheds cut with an axe and they do not require any finish-

ing. If an expert axeman is available this method saves time.

By the time several sheds are cut some of the other poles will be shaved. It may be said here that shaving is done by removing a thin layer of sap wood with a draw knife. Starting at the butt and working toward the top, the inner bark and discolorations are taken off and knots trimmed smooth, improving the appearance and leaving no room for moisture to lodge.

After the sheds are cut the center of the first cross arm is marked and the gain is marked half the thickness of the cross arm above and below. The location of the lower gains is then marked after which they are cut half an inch deep with the saw and finished off as described below.

It is found convenient to use the back of the hand saw to measure these distances. They are measured accurately with a rule and corresponding nicks are made in the back of the saw with a file. For instance, the center of the first crossarm may be ten inches from the apex of the pole; the distance of the crossarm from center to center, twenty inches; and the crossarms four and a quarter inches deep. Then the first mark for the upper cut of the first gain will be seven and one-eighth inches from the end of the saw. The second mark, for the hole for the crossarm bolt, will be ten inches from the end of the saw. The third mark will be for the lower cut for the gain of the first crossarm, at twelve and one-eighth inches from the end of the saw. The fourth mark is the distance from the lower cut for the gain of any crossarm to the upper cut for the gain of the next crossarm, at fifteen and a half inches from the end of the saw. These four marks are used over and over again for any number of crossarms, as follows: A right-handed framer stands facing the pole with the top of the pole to his left; he can then mark the two marks for the top gain, move the saw down, mark the next gain, and so on, cutting the gains as he moves down the pole.

Having cut the number of gains specified with the saw and taken care that they are at right angles to the axis of the pole by checking up with the steel square, the wood between the saw cuts is removed with the chisel. The surface should be left slightly hollow, the sides being perfectly level and smooth. The steel square should now be hung over the top gain and the second gain cut in exactly the same plane as the first. This is tested by laying the chisel on its side and sighting up with the edge of the steel square resting in the top gain.

The steel square must be left in the top gain and the lower gains made to agree with it, otherwise any slight error would be passed down the pole and added to a possible error below.

When all the gains are perfect the holes for the crossarm bolts are bored. The location of these holes should be measured in both directions. It only takes a short time to do this and all guesswork is eliminated. By "both directions" is meant the hole should be an equal distance from top and bottom as well as an equal distance from side to side. Having inserted the eleven 16x18-inch bit in the brace it will be found that leaving the steel square in the top gain is a help in guiding the bit. The holes should be perfectly level when the pole is set and at right angles to the crossarm in every direction.

To find exactly how accurately the holes have been bored the steel square is hung in each gain successively and the distance measured with the two-foot rule from the hole at the back to the vertical arm of the steel square. This should be the same as the corresponding distance on the face of the pole for each gain.

Locating Pole Steps

The location of the pole steps is next marked when pole steps are specified. The string is stretched the whole length of the pole in line with the holes for the crossarm bolts. Steps project from the front and back of poles and only from the sides at points where pole lines intersect, where, for the sake of appearance, the steps should be made to project in line with the most important thoroughfare.

Awls are used to hold the string in place. The first four steps are of wood. The first wooden step is two feet above the ground line, the second wooden step is five feet above the ground line, and the first iron step is eight feet above the ground line, with the rest at three-foot intervals to within eighteen inches of the lowest arm. Holes for the iron steps only are bored with the 9/16x8-inch bit to a depth of three and a half inches. The front of the pole is now completed so the string is removed and the pole is now turned over with the back up.

The other two wooden steps are located on the back, the first being three feet six inches above the ground line, the second is six feet six inches, and the first iron step on this side is nine feet six inches above the ground line. Poles are often supplied with steps from the office or cable terminal to the city limits, the idea being that these poles will be frequently climbed and that spurs would soon render them unsightly and make their renewal necessary.

Distributing the Poles

As they are completed the poles may be hauled away and distributed along the line. Instructions must be given to have the poles located correctly at each hole. The poles should be laid with the butt covering the hole and the top pointing towards the beginning of the line. This last instruction is not so important and may not always be possible. But it is a distinct advantage to have the hole covered by the butt until the pole is set because it prevents injury to stray animals by stepping in the holes and necessitates less work in setting the pole. In this connection it is obvious that where danger exists pole holes must be covered with something that renders them safe, therefore if the poles can be distributed as the holes are dug a saving is effected.

Another operation best carried out in the pole yard or "spot" where they have been unloaded is assembling the crossarms.

Cross Arm Assembling

One or two men are conveniently set to work on this while the poles are being framed. The insulator pins and crossarm braces are assembled on the crossarms by laying the crossarms in a row rounded side up and close together. A bag of pins is then spilled on them and afterwards the pins are inserted in the holes. Any that are not quite in place remain that way till their turn comes to be nailed when a tap with the hammer corrects matters. When the top layer of crossarms is full of pins a supply of carriage bolts, round washers, crossarm braces and shingle nails is arranged within reach.

Carriage bolts with round washers on them are now inserted in the nearest crossarm, it is then turned on its side and shingle nails are hammered in at each pin after which two crossarm braces are put on the carriage bolts and lastly the nuts of the carriage bolts. A Kelvin wrench is handy for tightening these nuts. With the crossarm braces laid along the length of crossarms they are now stacked for distribution.

As soon as the poles and crossarms are distributed the crossarms can be fitted to the poles on the ground. At the time the crossarms are distributed the truck should also distribute the crossarm bolts, square washers and lag screws, unless there is probability of these being stolen, in which case they will have to be taken in a conveyance with the man who fits the crossarms.

Cross Arm Fitting

To fit crossarms requires the following tools:

Rule, 2-ft., 4 fold
Steel square
Two monkeywrenches, 12-in.
Hand axe or heavy hammer
Awl
Pliers (lineman's)

The method of fitting crossarms follows:

A crossarm bolt has the nut removed and a square washer put on it. It is

now put through the pole from the back. To accomplish this with least trouble the top of the pole is raised by a "pole support" which is simply an "X" made of 2x4 stuff bolted in the center and wired across top and bottom. It should be of such a size that the top of the pole is raised about eighteen inches.

The crossarm should be within reach and is now slipped on and worked down into its place. A square washer is next put on followed by the nut of the crossarm bolt which is tightened with the wrench; the second wrench is sometimes necessary to hold the bolt from turning.

The crossarm braces are next turned down, one having its hole exactly over the hole of the other. An awl is then put at the butt of the pole on a line with the axis of the pole. A steel square is then used with its short arm along the crossarm and the long side is now sighted to be in line with the awl at the butt.

When the crossarm satisfies these conditions it is at right angles to the axis of the pole and the lag screw should be driven home.

The other crossarms are next fitted but are not sighted in but are fixed parallel to the top crossarm by measuring the distance apart at each end.

The lineman who fits the crossarms will be supplied with a coil of iron wire of specified size and a quantity of staples, also instructions as to the location of the poles which are to have lightning conductors installed, this information being taken from the specifications.

Lightning Wires

Having fitted the crossarms on such a pole the lightning conductor is installed as follows:

The pole is turned over on its face, the coil of wire is carried to the top of the pole and the end cut off diagonally so as to form as sharp a point as possible. The specified length is left projecting above the shed and the first staple enclosing the wire is driven in on a line with the bottom of the shed.

Now, the specifications may call for the wire to be run clear of the heads of the crossarm bolts, including the square washers. In this case another staple enclosing the wire is driven in two inches above the square washer and the wire is bent to one side so as to clear the square washer by two inches. Another staple encloses the wire here and the wire is bent down and descends at this place so as to clear all the square washers below. It is enclosed by a staple every two feet here. On reaching a point two inches below the lowest square washer another staple encloses it and it is bent to return to the center of the back of the pole where another staple encloses it. The wire is now unrolled to five feet beyond the bottom of the pole and cut off, retaining hold of it, however. A staple is next driven to hold it near the butt so that it will be straight right up to the crossarms. It is a help in tightening it to drive another staple below the ground line and pull the wire away from the pole between these two staples after which staples are driven in at the specified intervals.

The loose wire at the butt is made into a spiral and fastened to the bottom of the pole with three staples. This is the real ground connection and more wire here would seem an advantage.

Before leaving the subject it may be said that the fewer turns and bends in such a conductor the better, and the bends to avoid the pole hardware could be dispensed with by running the conductor down the side of the pole. It was found, however, that the conductor was in the way of the lineman's spurs when on the side of the pole, besides being unsightly.

Pole steps may now be installed if required.

Erecting and Setting the Poles

It will be supposed that the pole gang is composed of strong men able to do their share of lifting, shoveling and tamping. This is about as hard work as ordinary men can do regularly, and strong, willing workers only should be employed at it to obtain best results.

The tools required by a gang to erect medium small poles with about two crossarms are here given:

3 pike poles, 12 ft.
1 pike pole, 14 ft.
1 raising fork
1 cant hook
3 tamping bars
1 shovel
1 dipper pail
1 spoon

The procedure may be as described below:

A tamping bar is first put in the pole hole which should be emptied of water or other objects with the dipper pail or spoon. A man now holds the butt of the pole with the cant hook and the rest of the gang raise the pole by hand until the raising fork can be placed under it. They then move up, lifting the top of the pole higher, when the raising fork is moved up to take the weight. Now the four pike poles are pushed into the pole just above the raising fork; two men, one with the 14-foot pike pole, push directly towards the pole, the two others push from each side so that the pole will not be inclined to fall sideways. When all are in place, word is given to walk up. Each man then walks forward, the pole becomes vertical and falls into the hole.

The foreman now walks forward to the next hole and one of the men walks away about 50 feet, taking care to proceed at right angles to the line, starting from the pole. The pole is next turned to face in the opposite direction to the preceding pole, or to face a road or as directed in the specifications. The pike poles are then distributed around the pole and the pole is "lined in" with those already set or, if the first one, it is set as nearly vertical as the foreman can get it. When this stage is reached it will be found that it is leaning "forward" or "backward," and the "side liner" now directs it to be moved over at the top, whichever way is necessary. If the "head liner" does not consider any further correction necessary he raises his arms and drops them together to signal "O. K." and the men then ground their pikes to hold the pole while the hole is refilled and tamped. In doing this a small movement may have been given to the pole and the refilling is not started until final O. K. has been received from both the "head liner" and the "side liner."

One man now takes the shovel and distributes the finest soil around the pole and three men immediately begin tamping the soil round the pole. The foreman watches to see that none of these operations disturb the lining of the pole. The soil is tamped right from the bottom to the ground level or preferably three inches above. The shoveller then banks up the pole all around for a foot above the ground level and smooths this off in a neat and workmanlike manner. While he is so employed the rest of the gang collect the tools and move off towards the next pole.

It must not be thought that the work always proceeds as smoothly as this description but it will be found that the better each operation is performed the less trouble will be encountered.

Boom Forces Tampa to Double Budget

Tampa, Fla.—W. G. Brorein, president and general manager of the Peninsular Telephone Co., recently announced a supplementary extension program involving approximately $2,000,000 for this year. The original 1925 budget entailed a $2,400,000 expenditure for the great service demands of Tampa and the 14 surrounding points served by Peninsular.

Completing Golden Anniversary with Southwestern

St. Louis, Mo.—Louis H. Helsher of this city completes his fiftieth year of service with what is now the Southern Bell, on Oct. 4. When he entered the service as a messenger boy he was 14 and St. Louis had but 12 telephones.

Jacksonville, Ill.—Illinois Telephone company has bought the Winchester, Ill., plant.

The Unit Telephone Line

Second Article of a Group Devoted to the Subscriber Line. Some Pointers on the Installation of Inside Wiring and Substation Protective Equipment

By JOHN M. HEATH,
1st Lieut., Signal Corps, U. S. Army

6. *The Inside Wiring.* After the location of the instrument is agreed upon, the next thing for the installer to do is to run the several inside wires—either 2 or 3 conductor as shown in Figs. 2 and 3 (see p. 25, August TELEPHONE ENGINEER), depending upon the class of service to be furnished—from the place where the instrument is to be located to the protector, and also run one wire (the ground) from the protector to a water pipe or ground rod.

Inside wire for one-party service (Fig. 2) is made up of two No. 19 B&S gauge wires, rubber covered, braided, and twisted together, known as two-conductor. One wire has a tracer of red and the other a tracer of green spots.

The wire for two- and four-party service (Fig. 3) is made up of three No. 19 B&S gauge wires of the same covering and braiding as described above, all three twisted together, and known as three-conductor. One wire has a red tracer, and one a green, as described above, the third wire has a yellow tracer. The wire with the yellow tracer is always connected to the ground post of the protector, and runs to the instrument for selective ringing (see Heath's Handbook of Telephone Circuit Diagrams). If harmonic party selection is used the third wire is unnecessary.

Lastly the ground wire is run from the ground post of the protector to either a water pipe or ground rod. Ground wire is single strand No. 18 B&S gauge, rubber covered and braided, slightly heavier throughout than inside wire.

The installer conceals the inside wire as much as possible by running it in basements, closets, and behind picture mouldings, and also by "fishing" it behind walls and partitions wherever possible.

The installer should make just as little inconvenience to the subscriber during his work as possible and consistent with the proper performance of his duties, for it should be borne in mind that this is the subscriber's first impression of the company, and first impressions are the most lasting.

7. *Installing the Wire.* All wires installed within the building and on the station side of the protector are of either single, two-conductor, or three-conductor inside wire.

All inside wire should be installed in a neat, safe and workmanlike manner; in so far as possible inside wire shall be concealed or placed in such a manner as to be inconspicuous. Wires should not be run across finished ceilings. When it is impossible to conceal the wires, they should be run along doors or window casings against the plaster, or in the picture mouldings. Where there is no picture moulding, wires may be carried along the mop board or at the intersection of ceiling and wall. Where wire moulding is provided, wires should be run in it so far as possible. In no case should wire be carried across any open wall space at an angle.

When it is necessary to install these wires in cellars or in attics, great care should be taken to avoid possibility of damage from mechanical sources. Wet or damp localities so far as possible should be avoided for inside wire. Where such localities cannot be avoided, bridle wire should be used, or in extreme cases lead covered wire.

Telephone wires should not be run through hollow partitions, under floors, or in lofts, or other places where there is any liability of such places containing electric light wires on the concealed knob and tube plan, unless the telephone wires are continuously encased in approved conduit from inlet to outlet.

In installing telephone wires across electric light or power wires, the telephone wires should be pulled over the other wires in such a way as to avoid contact with them.

When it is necessary to cross pipes or other conducting material, telephone wires should be protected by insulating tubing, or by two wrappings of friction tape, the tubing or tape to project at least an inch on each side of such pipe or conducting material. Whenever practicable, all wires should be run above pipes or other conducting material that it is necessary for them to cross.

When it is necessary to cross an open electric light or power wire, the telephone wires should not come within two inches of these wires unless the telephone wire or wires be encased in interior conduit of approved quality or porcelain tubes and the maximum possible separation secured. When the telephone wires are so encased, the conduit or tubes should project at least three inches on each side of the electric light or power wire, and should be firmly secured so as not to slip out of place.

All wire should be fastened in such a manner as not to injure its insulation. For this purpose, wire fasteners are required, such as approved cleats, insulated staples, or insulated upholstery tacks driven between the wires. Uninsulated staples should not be used. If the insulated staples are driven over the twisted wires at the points of small diameter (with respect to the mounting surface) it will be satisfactory for the staples to enclose more than one wire. Care should be taken not to drive the fasteners through the insulation of the wires.

Where wires are run in channels or grooves in woodwork, fasteners should be spaced about eighteen inches apart, otherwise they should not be spaced more than twelve inches apart. In rounding inside corners, fasteners should be placed about one-half inch on either side, and the wire bent back into the corner. For use on soft woods and plaster walls, a seven-eights-inch tack is preferable to a one-half-inch tack.

When two-conductor wire is used, the wire having the red tracer should be connected to the "test" or battery side of the line, and the wire with the green tracer connected to the "dry" or neutral side of the line. When three-conductor inside wire is used the wires with the red and green tracers should be connected as above, and the yellow tracer wire should be connected to ground. The latter wire is the ringing-ground for two- and four-party lines, and coin box service.

Under no circumstances should spirals or coils be made in any of the wires at the protector or at the terminals of the telephone set, or in any other part of the substation wiring. There shall be no knots in any part of the substation wiring.

When necessary to splice wires of the telephone system within a building, the splice must be soldered and taped. In soldering wires, resin should be used as a flux for the solder; chloride of zinc, sal ammoniac or other acid fluxes must not be used. The joint must be carefully wrapped with two reverse layers of rubber tape and one layer of friction

tape. Corresponding wires must be spliced through, namely: red tracer to red tracer, and green tracer to green tracer, etc. Where twisted pair or three-conductor wire is spliced, the joints must be spaced at least four inches apart. Care should be taken to locate splices so that they will be neat in appearance.

Three or four inches of reserve wire should be left at the telephone set, provided it can be stored inside the set.

Any auxiliary set or extension bell forming a part of the substation apparatus should be attached to the circuit in such manner as to be protected in the same way as the substation set itself, and the wiring should be done in accordance with the general rules and specifications for inside wiring.

In case it should be necessary to run any part of the substation wiring on an outside wall of the building, such outside wall wiring shall be done with waterproof bridle wire.

The protector ground wire should run to a waterpipe, or permanent ground connection with as few bends as possible. There should be no spirals, coils, knots, or sharp bends in the ground wire. The ground wire should never be enclosed in iron pipe; if it is necessary to protect this wire from mechanical injury it should be enclosed in wooden moulding or a non-metallic conduit. The protector ground should never be run from the protector to the telephone set, and then to ground, and should never be twisted with the other inside wire, but if desired may be carried in the same run. When it is necessary to carry a ground wire through an outside wall, a separate hole, at least two and one-half inches distant from the circuit hole should be made for this purpose. The hole for the ground wire does not require a porcelain tube.

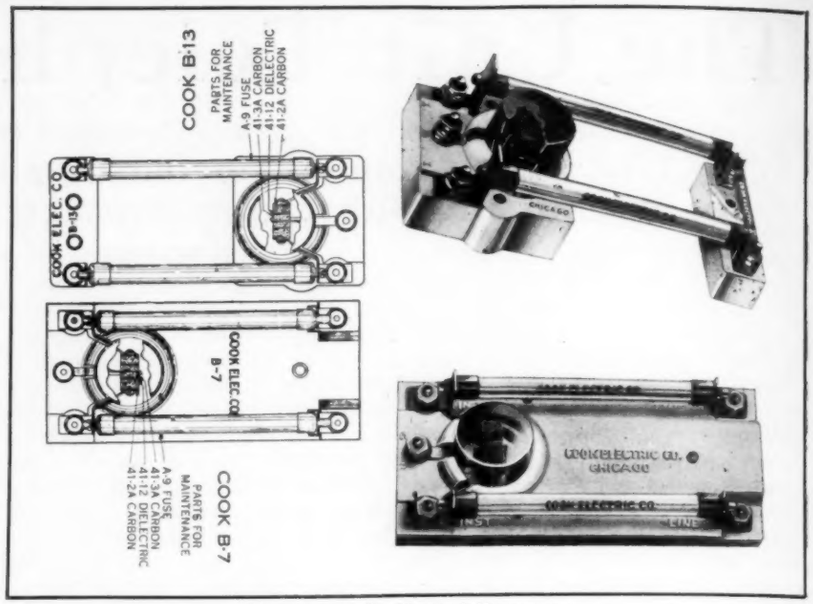
For individual protectors, the protector ground wire should be No. 18 B&S gauge copper insulated wire.

The ringing-ground for two- and four-party lines, i.e., the wire with the yellow tracer of the three-conductor inside wire, is connected at the protector to the same binding post as the protector ground.

8. *The Protector.* The protector, as its name implies, protects the house, inside wire, and telephone against high potential discharges from the outside, either from crosses with electric light and power leads, or from lightning discharges.

Telephone protectors are manufactured in a variety of forms. They all operate on the same principle, however.

Figs. 4 and 5 are typical forms. The two outside wires terminate on the fuses, and the two inside wires lead off from



Figs. 4 and 5—Typical Protectors.

the arrester end; the center point of the arrester end is wired to ground.

The operation of the protector is as follows: Each side of the arrester is fitted with a carbon block, separated by a mica (see Figs. 5 and 6). One form of carbon block is provided with a drop of solder that melts upon the passage of

Fig. 6—Form of Protector Mica.

excessive currents and fuses the two carbon blocks together. This carbon block normally rests against the grounded center post of the arrester, so when the drop of solder has fused there is a direct path from line to ground.

If the excess current is more than the capacity of the fuse the fuses open, thus opening the line.

The protector is the connecting link between the house wiring and the outside line. Placing the protector is in reality the second thing the installer does after he arrives at the subscriber's premises. After the protector is set the installer connects on the two outside wires and then proceeds to run the inside wire as hereinbefore described.

9. *Placing the Protector.* The location of the protector should be decided on before the entrance hole is bored, then one hole sloping downward from within should be made in the building, and this hole should, whenever possible, be bored from the inside of the building. Care should also be exercised to make the distance between the entrance hole and the protector as short as possible (see Fig. 7) and to locate both so as to give the shortest and most direct practicable connection to a permanent ground.

Twisted pair drop wires, extending from a pole or fixture to the building, are not terminated outside the building, but are brought into the building through the entrance hole. The distance from the last outside support to the entrance hole should not exceed twelve inches (see Fig. 8).

At the point where the lead-in wires pass through the hole in the building they should be protected by a porcelain tube projecting about one-quarter of an inch beyond the hole. Where building construction makes it advisable and where the projecting end of the tube will be protected, the porcelain tube may project one inch. The porcelain tube must be securely fastened in place.

Inside the building where it is impossible to run the lead-in wires direct to the terminals of the protector, they should be supported on porcelain from the end of the tube to the protector. It is important to make all work as neat as

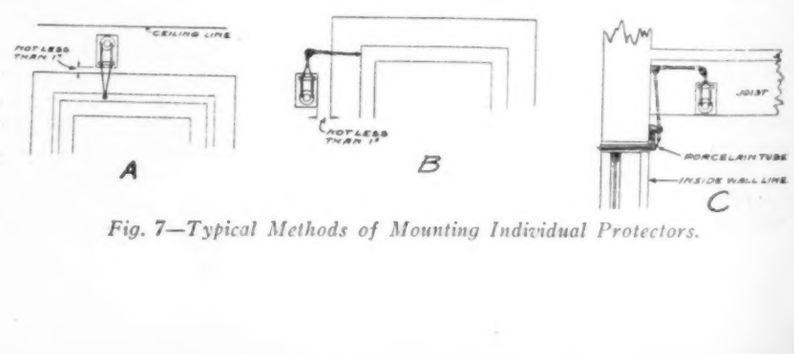


Fig. 7—Typical Methods of Mounting Individual Protectors.

possible and with this end in view the wires should be run only horizontally and vertically.

The lead-in wires must not come in contact with any of the building. If it should be absolutely necessary to extend these wires through floors, walls, partitions, timbers, or inaccessible places, they must be enclosed in porcelain tubes which project at least one-quarter of an inch on each side of the construction. The porcelain tubes must be firmly secured so that they will not slip out of place.

The lead-in wires shall be connected to the fuse terminals farthest away from the carbon blocks and the inside line wires should be connected to the terminals at the other end of the fuses, i.e., the end nearest the carbon blocks. The ground wire must be connected to the center or ground post.

The protector must be mounted on the wall, never upon the ceiling or floor, in such a manner that the fuses are vertical, otherwise the dust will collect between the carbon blocks and will not fall out. The protector should be placed as near as possible to the point where the lead-in wires enter. The protector must not be exposed to water or dampness. It should be fastened to the wall by screws, and so far as practicable be conveniently placed for inspection.

When the lead-in wires enter the building above a door or window casing, the protector is mounted on the wall away from the opening, not less than one inch from the casing. When practicable, the protector should be mounted at least seven feet from the floor. When curtains, shades, or like combustible materials are present, the protector must be mounted at least six inches away from such combustible materials. A protector should never be mounted in a show window.

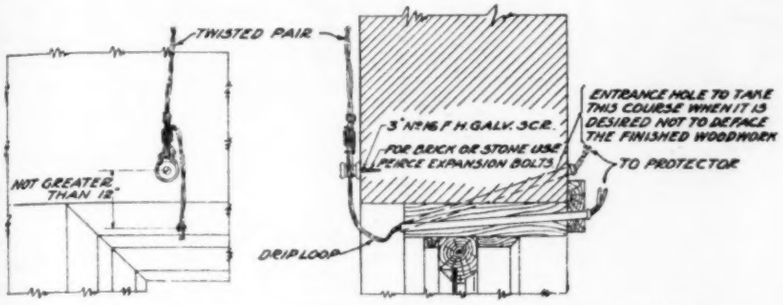

TWISTED PAIR
NOT GREATER THAN 12"
3" NO. 6 F. H. GALV. SCR.
FOR BRICK OR STONE USE PEIRCE EXPANSION BOLTS
ENTRANCE HOLE TO TAKE THIS COURSE WHEN IT IS DESIRED NOT TO DEFACE THE FINISHED WOODWORK
TO PROTECTOR
DRIP LOOP

Fig. 8—Method of Carrying One Exposed Drop into Building.

International Buys W. E. Unit

Western Electric Holds U. S. and Canada

New York City—International Western Electric Company has been bought by the International Telephone and Telegraph Company.

This important deal results in the Western Electric Company confining its activities to the United States and Canada, with the new International division enjoying Western Electric license agreements in foreign fields and acting as distributor for Western Electric American-made goods in foreign fields.

George E. Pingree, vice-president and general manager of the International Western Electric becomes its president under the new line-up, with Philip K. Condit, vice-president of the International Western Electric becoming executive vice-president under the now prevailing arrangement.

Details of the new financing necessitated by the purchase of additional properties are given in a letter sent to International Telephone and Telegraph corporation stockholders.

The International Telephone & Telegraph Corp. was incorporated June 16, 1920, in Maryland, to carry on a general telephone, telegraph, cable and wireless business, and business incidental thereto in the state, territories or dependencies of the United States, except the state of Maryland, and specifically to transact such business in Cuba, Porto Rico and other islands of the West Indies, Mexico, Central America and South America, as well as in other foreign countries.

The corporation owns approximately 97 per cent of the common stock of the Cuban Telephone Co., and about 97 per cent of the common stock of the Porto Rico General Telephone Co. and South Porto Rico Telephone Co., both incorporated in 1906. In addition the corporation owns jointly with the American Telephone & Telegraph Co. all the stock of the Cuban American Telephone & Telegraph Co., forming the connecting link by telephone cable between Cuba and the entire Bell system.

The American Telephone & Telegraph Co. and International Telephone & Telegraph Corp. officials have denied existance of any financial affiliation between the two, other than the joint operation and ownership of the cable between Key West and Cuba.

The International Western Electric Co. and its affiliated companies have holdings which include full or partial ownership in telephone manufacturing plants in London, Antwerp, Paris, Vienna, Budapest, Barcelona, Milan, Tokio and Peking, with sales offices at various points in Europe, Africa and South America.

In the annual report for 1924 of the Western Electric Co., it was stated that the export billings from the United States by the International company were $6,773,000, of which the Western Electric Co. furnished $4,273,000, a substantial increase over 1923. The International company's net earnings in 1924, exclusive of a special dividend from past earnings of the London company, were $1,477,000, which amount was sufficient to provide for interest, dividends at the rate of 7 per cent on its preferred stock, and for the usual dividend of $1.40 a share on the common stock with a substantial balance.

The International Western Electric Co. also is active in the radio field and its radio facilities are expected to prove an important factor in the International Telephone & Telegraph Corp.'s plan for telephone service development abroad.

Radio broadcasting has not developed so rapidly abroad as in the United States, but broadcasting associations in which the International company's associates have some part have been licensed by the government of Italy, Spain, Norway and Japan. Manufacturing of radio apparatus is carried on in all the associated factories of the International Western Electric Co.

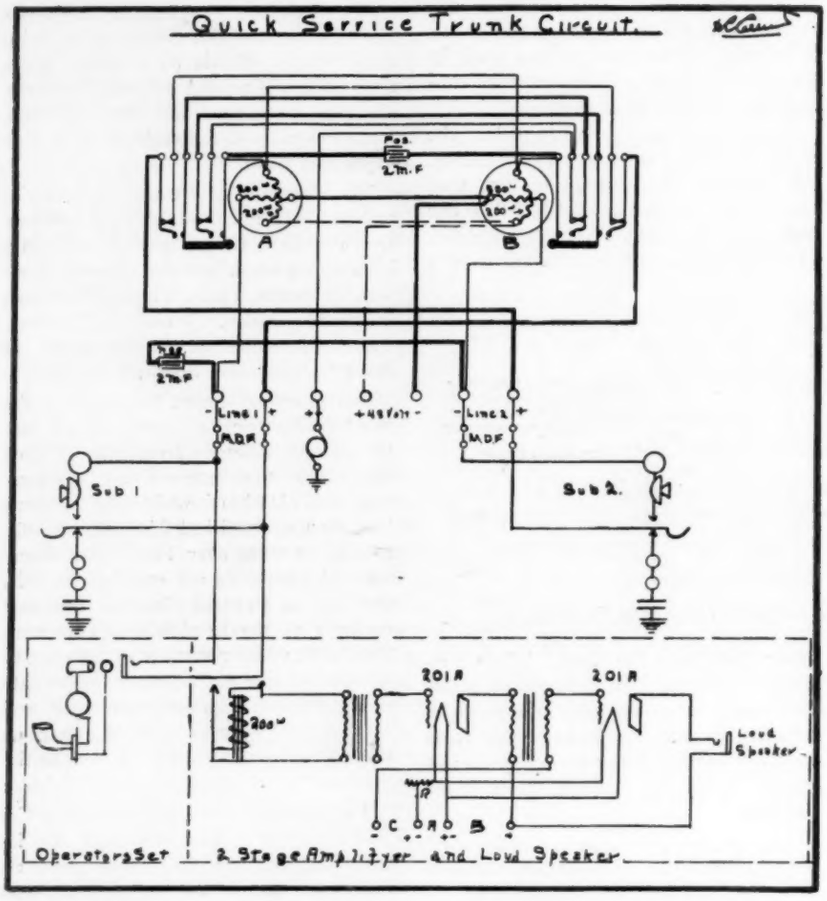
The International Telephone & Telegraph Corp. also announced that it has acquired a controlling interest in the Mexican Telephone & Telegraph Co., operating telephone systems in Mexico City and a number of other Mexican cities.

The Mexican company has recently been granted two new concessions for the operation of telephones in Mexico. One of these concessions grants the right to construct and operate a long distance telephone system in Mexico. The other is an extension of the existing concession in Mexico City and vicinity.

Two Way "Rush" Trunk

Ingenious Installation in Canada

By S. V. COLLINS



A local brokerage firm made a request for a direct line between their office and the telegraph office for the purpose of obtaining market quotations. They asked for a line that would enable them to call either way by simply removing the receiver from the hook at the calling end, with an arrangement for stopping the ring by removing the receiver at the answering end. Since the lines were located in two different parts of the city, a local battery system was not feasible. Since the system would be in use for hours at a time, dry cells for transmitter battery supply would be unsatisfactory.

A search through our text books or magazines failed to discover any such circuit, so we developed the one which is described herewith.

The equipment at the central office consists of two relays and two condensers mounted in a bell box. The condensers are 2 M. F. each. The relays are double wound, with 200 ohms to a side. Each relay is equipped with two sets of make-before-break springs. This feature is necessary to prevent the relays from chattering instead of operating their full armature stroke.

The relays we used are the horizontal type automatic switch relay, made by the Automatic Electric Co. However, their manual type relay can be obtained to give the same assembly. The Stromberg-Carlson Co. and the Western Electric Co. also can supply relays of the design required. For use with 48 volts the 200-ohm windings are necessary to prevent overheating. With 24-volt battery relays wound to 100 ohms per side will be needed.

One battery lead, a generator lead with a 15-watt 110-volt lamp in the live side and the two line pairs are connected to a terminal strip in the bell box. At the telegraph office, a desk telephone with a head receiver were installed. At the broker's office a wall telephone and an operator's chest transmitter and receiver set with plug and jack were installed. The ringers at each telephone were grounded through the condensers and connected to the positive side of the lines. The Automatic Electric Co. set provides for the ringer to be cut off when the receiver is removed. This is not necessary, however, except where power lines or street railway systems cause too much disturbance to the talking. In such case it would be best to arrange both the sets as shown in the drawing, also use "s" type of jack that would also cut the ringer out at the broker's office.

A two-stage amplifier and loud speaker can also be used so that the quotations are heard by the clerk at the blackboard, as well as the audience at the broker's office. When this is used, a 200-ohm retardation coil should be bridged across the primary of the first audio transformer, to provide a holding circuit for the exchange relay. The operator's set, however, will be possibly the best, as it affords the blackboard clerk a means of checking back with the telegraph office in case of error. The operator's cord should be long enough to enable him to reach every part of the blackboard easily.

The operation of the circuit can be traced as follows: When the receiver at Sub. No. 2, the telegraph office, is taken off, battery from the negative winding of relay B flows over negative line No. 2, through receiver and transmitter, and make contact of hook switch at set No. 2, positive line No. 2, normal contact of relay A to positive winding of relay B. This causes relay B to operate. The office generator being grounded on one side, generator current will now flow through normal contact of relay "A," make contact of relay "B," positive line No. 1, normal contact of hook switch at sub. No. 1 through ringers and condenser to ground. The subscriber at sub. No. 1 either takes off the receiver of his wall set or plugs into the extension jack. Generator will now momentarily flow through transmitter and receiver in series, negative line No. 1 through negative winding No. 1 and battery to ground. Since the office battery is also grounded, the one alternation of the ringing current and the 48-volt battery in series will give an effective pull of about 150 volts through the negative winding of relay "A." This will cause relay "A" to operate.

It will be seen that relay "B" has part of its circuit taken through relay "A" contacts, hence the make-before-break springs to prevent "B" from restoring. Then since the generator is taken through the normal contacts of relay "A," the make-before-break contacts are necessary to allow "A" to complete its armature stroke and bring the positive winding into the circuit.

With both relays operated, a balanced battery feed is supplied to each telephone using the relay windings for the choke coils. The two condensers provide the talking link between the two telephones.

The talking circuit can now be traced by the heavy lines. From negative terminal No. 1, negative condenser, negative line No. 2, telephone No. 2, positive line No. 2, make contact relay "A," make contact relay "B," positive condenser, make contact relay "A," make contact

The telephone door

More people enter our homes and offices by telephone than in person. Through the telephone door, traveling by wire, comes a stream of people from the outside world on social and business missions. Important agreements or appointments are made, yet the callers remain but a few seconds or minutes and with a "good-bye" are gone. We go out through our telephone doors constantly to ask or give information, buy or sell things, make personal calls and on dozens of other errands.

None of the relations of life is more dependent upon co-operation and mutual consideration than these daily millions of telephone journeys. It is the telephone company's part to furnish the means of calling and to place courteous and intelligent employees at the service of the public. Good service is then assured when there is a full measure of co-operation between users.

Only by mutual care and consideration can everyone enjoy the full pleasures and benefits of calling. Telephone courtesy is for the good of all who use the telephone door.

AMERICAN TELEPHONE AND TELEGRAPH COMPANY
AND ASSOCIATED COMPANIES

BELL SYSTEM

One Policy, One System, Universal Service

relay "B," positive line No. 1, telephone No. 1, negative line No. 1. This is a standard telephone circuit and gives excellent transmission. The common battery feature permits of the two offices being located in any part of the exchange area.

Burkeville, Va.—Plans are being made for a new office building by the Burkeville Telephone company.

Nashville, Tenn.—Oscar S. Evans has been made division commercial manager here for the Cumberland.

Finish 861 Mile Cable

New York-Chicago Line Equivalent to Ten Pole Lines

Another great arterial highway in the voice communication system of the United States was completed Tuesday, August 11, when the last splice was made in the New York-Chicago cable of the American Telephone and Telegraph Company. The final splice was made near Swanton, Ohio, about twenty miles west of Toledo, by Frederick A. Stevenson, director of the Long Lines Department of the A. T. & T. This brought to a finish work which has been going forward under a definite plan for about seven years.

The last splice was made from a platform erected beneath the line and in the presence of a number of prominent telephone officials, including the following:

American Telephone and Telegraph Company, general headquarters—J. D. Ellsworth, assistant vice-president; H. G. Stokes, information department; H. P. Charlesworth, plant engineer, department of operation and engineering. Long Lines Department—T. G. Miller, general manager; J. J. Pilliod, engineer; L. N. Stoskopf, general plant manager; T. T. Cook, assistant to director; Sydney Hogerton, division plant superintendent; W. K. Migrath, division superintendent of line construction; Thomas Higginson, plant department, Chicago.

Illinois Bell Telephone Company—W. R. Abbott, president.

Indiana Bell Telephone Company—C. H. Rottger, president; W. H. Curran, chief engineer; George B. Wellbaum, publicity manager.

The Ohio Bell Telephone Company—C. P. Cooper, president; Randolph Eide, vice-president and general manager, G. A. Kositzky, chief engineer.

The first demonstration of the new cable took place at ten o'clock Friday morning, August 14, when President W. S. Gifford of the American Telephone and Telegraph Company, from the headquarters building in New York, called Mr. Abbott in Chicago. Mr. Abbott congratulated Mr. Gifford and the A. T. & T. engineering and construction forces, who had so successfully completed the monumental work, and also exchanged greetings with Mr. Stevenson, E. S. Wilson, vice-president; J. D. Ellsworth, assistant vice-president, and H. P. Charlesworth, of the department of operation and engineering. A photograph of the scene in Mr. Abbott's office was then transmitted to New York by the Bell System telephotograph process.

Cable 861 Miles Long

The New York-Chicago cable is 861 miles in length and is the longest telephone cable in the world. The route selected after careful studies of service requirements and all other requirements is from New York to Morristown, N. J.; Reading, Harrisburg, Pittsburgh and New Castle, Pa.; Akron, Cleveland and Toledo, Ohio, and South Bend, Ind., to Chicago. Construction has been in progress about seven years, and the cost when the cable is fully equipped will amount to approximately $25,000,000.

OUTSTANDING FACTS ABOUT THE BIG CABLE

Length over all, 861 miles.

Contains 447,000 miles of wire.

250 telephone conversations and 500 telegraph messages can pass through the cable simultaneously.

Diameter is 2⅝ inches.

35,700 poles support the 717 miles of the aerial sections.

144 miles of the cable is underground.

Total weight, approximately 34,750,000 pounds.

Weight of the sheath, 21,350,000 pounds.

9,500 separate lengths are combined in the cable.

Wire splices totaled 5,750,000.

Time required for construction, 7 years.

Chief advantages secured by using cable instead of open wire construction are that it is much less liable to damage from storms and it provides a large number of circuits in a small space.

Telephone repeaters used at 17 points, in addition to Chicago and New York.

Total cost, $25,000,000.

While there are changes in the designed cable to meet variations in circuit requirements and other conditions in different sections, the cable is in general made up of 500 to 600 No. 16 and No. 19 gauge copper wires. These wires are each wrapped with paper for insulation and all wires are twisted into pairs which are then twisted into quads, two pairs to the quad. The quads are arranged in concentric layers and the whole is covered with a lead-antimony sheath about two and five-eighths inches in diameter. Loading coils are connected to the wires at intervals of approximately 6,000 feet, and repeaters are connected to the circuits at intervals of either fifty or one hundred miles. The cable was placed in underground conduit for 144 miles through cities and in the open country was installed on poles for 717 miles. About 35,700 poles support the aerial sections. Wire contained in the cable totals 447,000 miles. The total weight is approximately 34,750,000 pounds, of which the lead sheath weighs 21,350,000 pounds. In round figures, 9,500 separate lengths are combined in the cable. About 5,750,000 wire splices were made.

The cable will provide 250 telephone circuits and more than 500 telegraph messages can also be sent simultaneously with the telephone conversations. To provide facilities for the same number of telephone and telegraph circuits by open wire construction would require about ten heavily loaded pole lines of the usual type.

Prior to the use of cables for long distance telephone circuits it was necessary to use the familiar type of open wire construction with forty to sixty separate wires carried on a single pole line. This type of construction is subject to some interference from severe storms, particularly when the wires are loaded with sleet. Furthermore the number of routes which it is practicable to utilize for long distance lines of this kind is limited. Many years ago it was found necessary to use cables instead of open wire construction in local exchange telephone plants in large cities. The problem of long distance telephone service through cables is distinctly different from the problem involved in the use of cables in local exchange plants, but after a large amount of research and engineering work, long distance telephone service through cables was successfully accomplished and cables have been utilized for this purpose for a number of years in various sections, as, for example, from Boston to Washington, 450 miles. Following the successful operation of these cables and the better service which was thereby made available to the public, consideration was given to the use of cables for

Here's a great book we want to hand to executives

IT'S the new catalog of Gray Telephone Pay Stations. "Catalog" is a rather drab word to use in classifying this book, for it's far more than a mere presentation of the mechanical details of Gray Telephone Pay Stations.

It is a book that is a very interesting and profitable volume for the telephone company commercial men for it details the development of telephone business with the Gray Pay Stations. And it's of absorbing interest to the engineers for it shows in the story of the Gray Pay Stations, one of the "close-up" chronicles of Yankee inventive genius. Incidentally, did you know William Gray, inventor of the first Gray Pay Station, also was inventor of the inflated baseball catchers' protector?

In its contents and the way it's put up, this is really a valuable book. It has been our effort to place this Gray book in the hands of every telephone company executive who really could use it to advantage. If you haven't your copy, write us, on your company stationery.

The Gray Telephone Pay Station Company
Main Office and Works, Hartford, Conn.

GRAY PAY STATIONS

longer distances in other sections. After a thorough study of the situation it was decided to install a cable from New York to Chicago.

Is Part of Larger System

While the New York-Chicago cable is the longest telephone cable in the world, it is only a part of a comprehensice cable system which in a few years will link many of the important centers in the more densely populated sections of the country east of the Missouri and north of the Ohio and Potomac Rivers. This cable is designed to operate as an extension of other existing long toll cables, such as the Chicago-Milwaukee cable. It is also designed to operate in connection with cables which are under construction or planned, such as the cable from Chicago to St. Louis, 300 miles, to be completed in 1926, and a cable from New York via Albany and Buffalo to Cleveland, which is under construction.

Existing open wire lines will not be displaced as a result of the installation of this cable system, but to some extent the wire loads can be reduced where the routes are closely parallel. It is expected that open wire lines will continue to be used indefinitely in many sections so that the cables and open wire lines will supplement each other.

Rubber Insulation for Submarine Cables Approved

Washington, D. C.—The use of submarine cables is increasing, and new cables are being laid all the time, says the Bureau of Standards of the Commerce Department in announcing the results of a study of material suitable for cable insulation. The cable which stretches under the seas consists of copper wire insulated with gutta percha and protected by steel armor wires wrapped around the outside. The construction today is practically the same as for the early cables.

The largest item in the cost of manufacturing a submarine cable is the cost of gutta percha for the insulation, which amounts to more than all other items together.

An investigation carried out by the Bureau of Standards undertook the study of gutta percha, rubber, and rubber-like materials to find out what material was the most suitable for submarine cable insulation. The aim was to find a material which was more available than gutta percha and yet serve the purpose as well. Accordingly, the electrical properties of both rubber and gutta percha have been studied with care.

Much work was done on rubber, because rubber, as used in the arts, is not a simple substance, but is really a mixture of vulcanized India rubber with a variety of inert materials. Electrical insulation such as is used in house wiring may contain only 20 or 30 per cent of rubber. The materials which are added to rubber are by no means to be considered as adulterants. They modify the properties of the rubber to suit the use.

In order to find out the kind of rubber insulation which would be most suitable for use in making a submarine cable, it was necessary to study the effect that a great many materials had on the electrical properties of rubber. Because the investigation covered rubber in so many combinations, the results will be of use wherever rubber is employed for insulation. Many of the combinations of rubber which were studied and found to have electrical properties totally unsuited for submarine cables may have just the characteristics needed for some other purpose.

The conclusion was reached that rubber insulation may be made which has the properties needed for submarine cable insulation, in some respects being superior to gutta percha.

Western Red Cedar Association Establishes Research Division

Spokane, Wash.—At a special meeting of the Western Red Cedar Association recently held here a research division was established and Kurt C. Barth was appointed director. Offices have been located in Chicago. The program outlined for the research division contemplates complete service, alike to the consumers and producers, providing an agency whose duty is to advance their mutual interests. Among the more important features are the co-ordination of producing conditions with consumers' needs, and vice versa; a collection of physical data, service records, and all technical information helpful to engineers and buyers responsible for the employment and purchase of western red cedar poles. Constant attention is to be given to all factors of production, distribution and consumption, including preservative treatment, so that the product of each member of the association may be maintained at the highest standard of quality and value. To this end every effort will be made to co-operate with all technical and other organizations interested in, or dealing with, conductor supports.

From time to time pertinent literature will be made available for general distribution, but in a large measure the service offered to pole consumers must of necessity be of a more personal nature, dealing particularly with specific problems. Those desiring information about western red cedar poles should address the research division, Western Red Cedar Association, 5 South Wabash avenue, Chicago.

Indiana in Three-Day Meet September 22-24

Indianapolis, Ind.—Indiana's first three-day convention is to be held at the Claypool, September 22, 23, 24. An intensely practical program is being lined up, with plenty of time allotted for discussion and inspection of exhibits.

One of the sessions is to be devoted to consideration of long distance and local operating problems, and executives are urged to have their chief operators attend this part of the convention. "Better State-Wide Service" also will be one of the featured topics of discussion. State officials also will shine on the program.

It is planned to make this Indiana banquet the best the state ever has held.

Illinois Plans "New Idea" Meeting Nov. 18-19

Springfield, Ill.—President Norris, Secretary-Treasurer Mitchell and other officials of the Illinois Telephone association are planning the annual Illinois convention for the Jefferson Hotel, Peoria, November 18-19. Considerable thought is being given the convention program which is promised to be "along new lines" and to "be one of the most constructive telephone gatherings ever held."

Reservations for rooms and exhibit spaces should be made direct to the hotel. Every possible co-operation will be extended exhibitors and other attendants by the association. Jay G. Mitchell of the association at 311½ South Sixth street, Springfield, will supply any desired further information concerning the convention to inquirers.

New Yorkers in Practical District Meeting

Plattsburg, N. Y.—With all the spirit and interest of an old-time revival meeting executives, department heads and operators of the northeastern district of the Up-State Telephone association of New York lit into their problems and got considerable help in their battles during the third annual one-day meeting of the group.

Plant, accounting, operating and commission subjects were given the benefit of expert treatment by a number of well-known New York state telephone men and women who attended the lively affair.

There are seven billion more telephone calls than letters and post cards in the United States annually.

Tokio, Japan—From 1925-1930 50,000 telephones a year will be installed by the Japanese government.

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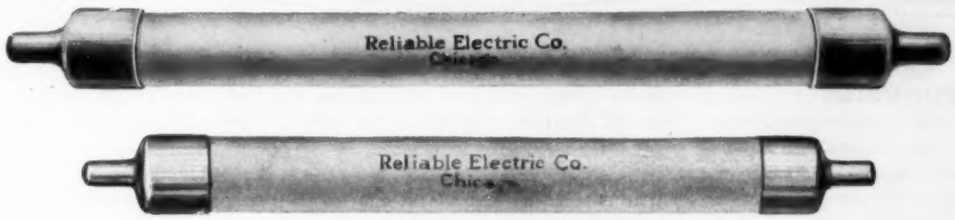

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They "BLOW RITE" and withstand rough handling.

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Good "hoss sense"

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Compare the remarkably slight cost of installing cable underground without conduit by using EVER-PROTECT Cable Compound with the cost of

storm line damage
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There's no other outcome than an urge to immediately make the EVER-PROTECT installation.

Hundreds of the best managed telephone companies have been using EVER-PROTECT years and they've all made and saved money with it.

Better consult your nearest live jobber right now and see just why you should get EVER-PROTECT on the job at once.

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LINE AND DESK

AN EARLY CABLE PULLING AUTOMOBILE

The extensive use of motor equipment in present day line construction makes of interest the following story from *Southern Telephone News* of an early application of the automobile to the job of pulling cable. Can any of our readers tell us of an earlier application?

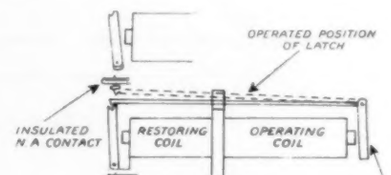
"In the summer of 1905, W. R. Parker, now superintendent of construction in the Mississippi division, was doing construction work in Clarksdale, Miss., which called for placing a twenty-five pair cable in an alley at the rear of the old Alcazar Hotel. No mule or horse team was available for the job of pulling the cable, so a still more primitive contrivance or machine known as a crab was put to use. The method in which the crab operated was very much like the old well windlass which can still be seen in some remote places. The crab was chained to the first pole ahead of the pole on which the cable was to terminate, one end of the pulling line being fastened to the drum of the crab, the other threaded through the cable rollers and tied to the end of the cable. After everything was made fast, by turning the crank the winding began and the cable crept into place.

"W. J. Tomerlin, now manager at Springfield, Tenn., was at that time manager at Clarksdale and was an interested onlooker at the time the crab was in action. Mr. Tomerlin, noticing the extreme slowness of the process, approached Mr. Parker and stated that he had an idea which might work and if so would save quite a bit of time. Mr. Parker gave his consent for the use of any scheme which would hasten the work, so Mr. Tomerlin disappeared but returned shortly with H. J. Davis and his Oldsmobile, which he had purchased from a wholesale bicycle dealer at Memphis. This was the second vehicle of its kind that Mr. Parker had ever seen and naturally he was more curious and dubious than enthusiastic as to its success, but he was more than willing to try it out.

"By the manipulation of complicated levers, the one-cylinder chain drive automobile, but little heavier than a buggy, was steered into position and replaced the antiquated crab. Mr. Tomerlin took the driver's seat and reached for the throttle. The slack was soon taken up in the pulling line, more gas was applied and the wheels began to spin, raising a cloud of dust, but the new cable puller made no forward progress. A review proved that ballast was needed for the prime mover, so two of the heaviest men on the job were ordered to ride the rear axles. This solved the problem, as the automobile forged ahead, pulling in the whole section of cable in but a few seconds."

A CASE OF NIGHT ALARM TROUBLE

Recently when I came to the office in the mornings I found a number of trouble tickets reading, "Night bell does not stop ringing at times." After testing for the usual cause of this trouble, due to the failure of contacts to break, I asked for more particulars and was told that the bell sometimes rang continuously when connections were up but was O.K. when all cords were down. Further testing located the trouble in drop No. 117. The drops are of an electrically restored type with operating and restoring windings on the same core. When a plug is in the line jack the armature is attracted but the drop shutter is held up by the restoring winding. The night alarm circuit is closed when the drop falls through an insulated contact mounted below the shutter. The trouble was located when it was discovered that the latch of the drop on line 117, which was lifted as long as a plug was in the jack, was making contact with the adjusting screw of the night alarm contact on the drop immediately above. A little adjustment was all that was needed to remedy the difficulty.—Contributed.



TEST OF TELEPHONE WIRE

A telephone manager writes us as follows: "The sample of wire which I am sending is being sold to a good many small telephone companies near here. Can you tell me where I can have it tested for strength, conductivity, galvanizing, etc.?"

The sample looks very much like what is known as ordinary single galvanized steel fence wire. It is less pliable and the galvanizing is not as good as that of BB wire which is most commonly used by telephone companies. If this is the case, it will be found that the strength is about 12 per cent greater than BB wire and the resistance is about 18 per cent greater. Rather complete information regarding iron wire for telephone use was given in the article by P. Kerr Higgins, "Iron Wire in Telephone Work," which appeared in the November, 1924, issue of TELEPHONE ENGINEER, p. 21. This article gives in detail the test for galvanizing which you can easily make yourself. Briefly the test consists in four immersions for one minute each in a solution of copper sulphate (blue vitriol) made in the proportion of 36 parts by weight of the copper sulphate to 100 parts by weight of water. If the sample shows deposits of copper after the four immersions, the galvanizing is below that ordinarily accepted as standard for telephone wire.—Staff Contribution.

TO PREVENT AUTO FIRES.

Carelessness with regard to smoking and the use of open-flame lamps often is responsible for fires and explosions when filling gasoline tanks. At such times, truck engines should be stopped and kerosene and acetylene lamps should be extinguished, and there should be no smoking in the vicinity of the gasoline. Cases have been known where careless or thoughtless persons have used lighted matches to determine the amount of gasoline in the tanks, but the actors in such performances commonly become subjects for the doctor or the undertaker. A necessary and important precaution in filling a gasoline tank is to make sure that the metal nozzle of the filling hose remains in contact with the metal of the tank, in order to prevent the accumulation of static electricity and the consequent generation of sparks which might ignite the gasoline fumes.—"Travelers' Standard."

AN ODD CASE OF U. G. CABLE TROUBLE.

Trouble in underground cable from rather an unusual cause occurred recently in Baltimore and is described thus in "The Transmitter":

The cables in an alley near McMechen st., run directly above a 6-inch water main. An old plug in the water main burst, sending upward through the ground a small stream of water, under seventy-pound pressure.

Through the force of the water, and the rapid churning of sand and dirt, a hole was worn in the conduit, and the sheathing on a 300-pair cable torn apart and flattened. The wires in the cable were mashed against the top of the duct at the point of contact with the water, and became wet for a considerable distance.

A 430-pair cable was also affected, but to a smaller extent.

Trunks connecting the Plaza, Madison, Vernon, Liberty and Forest offices were put out of service, but as other trunks were available, no office was completely without service to the rest of the city. Calls between some of the offices, however, were handled on a delayed basis for one day.

Plant forces were on duty as soon as the trouble was discovered, and started replacing the damaged cables as soon as the water could be shut off. About 400 feet of the 300-pair cable and a short section of the 430-pair cable had to be replaced.

THE CABLE MAN AND HIS TOOLS

Some valuable suggestions for safe handling of the tools of the cable-splicer's job are given in the following extract from a paper by Arthur Hindle in Telephone Topics:

Tools and material should be placed in orderly manner, at a safe distance from the manhole without interference to traffic.

Edged tools should always be protected.

Tools should never be thrown.

Furnaces, if handled improperly, are treacherous. Instructions in their use should be followed at all times.

A lighted furnace should never be transported.

A furnace should never be pumped before it is heated, time for generation should be allowed.

A furnace should never be pumped until paraffin or solder pot has been removed.

Carrying electricians' scissors in shirt or vest pocket is a dangerous practice. Many times have I seen them slip out of the pocket into a manhole, causing the splicer to jump clear. Falling scissors are especially dangerous to the eyes.

Ropes used in connection with aerial work should always be in good condition and not allowed to hang loosely.

Ladders and platforms should be kept free from paraffin wax.

It is false economy to try to "get by" with defective tools. Someone may have occasion to use the tool not knowing of the defect.

Wiping cloths should be in good condition. It is surprising to see how often a man will use a wiping cloth after the first layer is burnt through. It simply makes a nice pocket for molten solder which usually rolls back into the palm of the hand or on the wrist of the splicer, causing a very painful burn.

"TROUBLE SHOOTER" RIGHT NAME FOR THIS GENT

Not long ago, Byron Puleston, section patrolman on the transcontinental telephone circuit between Chicago and Los Angeles, was sent out on a forty-mile trip where, according to the calculations made by the toll testboard man in El Paso, trouble had developed on the line. This was in the vicinity of Cutter, N. M., which might truly be termed one of the "great open spaces." As Puleston described it, "it is about as far from anywhere else as a place can be and still be anywhere."

When the patrolman reached the spot,

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Dry battery expense ordinarily is 6% of the average magneto telephone income, according to reliable authorities.

We've checked over the figures with a lot of users of Victor dry batteries, and the battery cost is sharply less than 6%.

The reason for this saving is readily seen when you consider the unique construction of Victor batteries. Victors have the thickest zinc shell, densest compound, special paste and liners to prevent action within the shell, and a number of other points of superior construction that account for longer, livelier life.

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Double Galvanized Telephone and Telegraph Wire

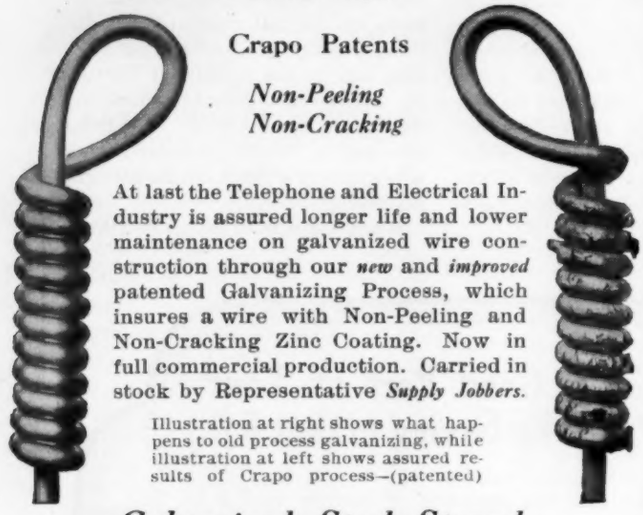

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Illustration at right shows what happens to old process galvanizing, while illustration at left shows assured results of Crapo process—(patented)

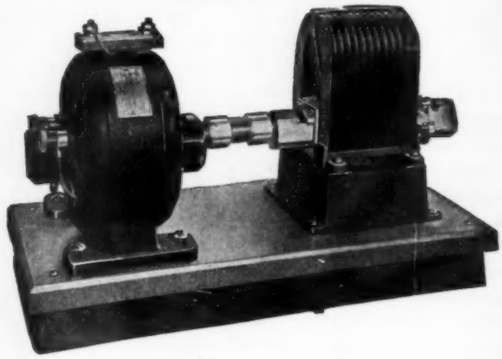
Galvanized Steel Strand

Standard or Commercial, Siemens-Martin, High Strength and Extra High Strength Grades

Indiana Steel & Wire Co., Muncie, Ind.

Dependable Ringing Service —with Economy!

A Holtzer-Cabot Magneto Ringing Motor-Generator



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When the best protection costs no more, why not have it? BRACH arresters insure; non-grounding of lines, cables, clear transmission, balance of potential between pairs, and full protection against power crosses or lightning. There are no carbons to clean and no maintenance bills.

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A R-L cord to fit any make of telephone or switchboard

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DEPENDABLE SINCE 1904

he found nothing wrong and so reported, then starting back on his long trip. After he had gone about twenty miles he was intercepted and ordered back, as the trouble had recurred. Again he reported nothing wrong and set out on his return, and once again he was ordered back. He still found nothing at fault, but was ordered to camp on the job and await developments.

In the dusk of the evening a large number of ravens appeared. They assembled on the circuit to talk things over, finding a phantom transposition a very convenient roosting place. Puleston broke up the meeting and moved for an adjournment, and the big birds moved over to the wires, which sagged down and made solid contact with a lower wire, this being the direct cause of all the trouble.

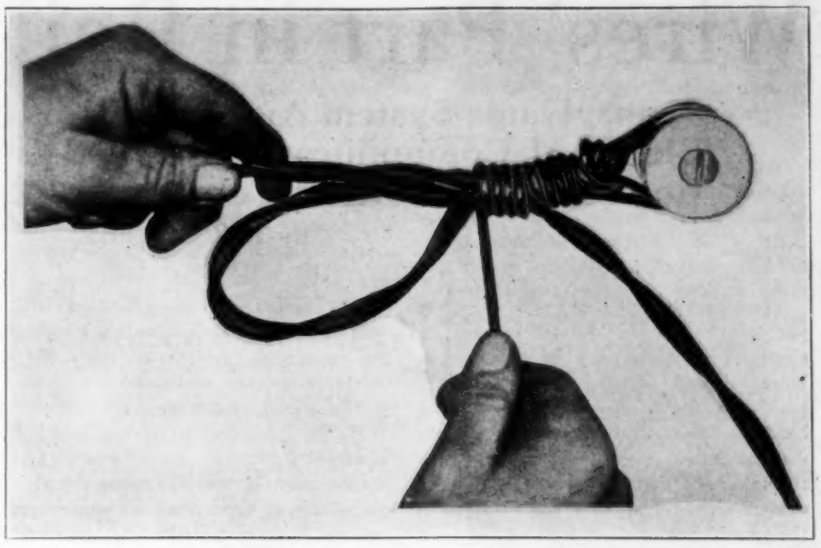
Puleston then rigged up some scarecrows, which he mounted on top of the poles. But the ravens made friends with them as fast as he put them up, so that he had to resort to a shotgun. Then he decorated the crossarms with several husky specimens which had become defunct, but it took about three days and nights to get the idea across to the rest of the ravens, when they eventually took the hint and departed.

WHERE THE ANCIENT AND MODERN MEET.

Herewith are two photographs of an old gate, showing a grounded telephone circuit going through the top part, to save a pole. This gate is situated at the entrance of Santa Rosa on the Manila south road, 40.9 Kilometers from Manila. Picture No. 1 shows the gate complete, while No. 2 shows the detail of the wire, going through the belfry-like part on top of the gate.

Line Strung on Ancient Manila Gate.

Beyond this gate, where the timber is dense, this same line is strung for miles, suspended between trees in the middle of the road, like a trolley. This method of construction not only saves poles but gives a good tree clearance. Many bamboo poles are used.—Ray Blain, Telephone Plant Engineer, U. S. Department Signal Office, Manila, P. I.



Method of Making "Mule's Ear" Dead-End Tie.

WE USE 600 TOOLS

The Michigan Bell's chief engineer, Carlyle Kittredge, is authority for the statement that, during the past five years, approximately 250 new tools have been developed and standardized for construction and maintenance work. In addition, about 160 have been improved from the standpoints of manufacture, cost and efficiency. About 600 tools are a part of the Michigan Bell's standard supplies. It has been estimated that the average carpenter uses about 30 tools, an electrician uses 25, and an automobile mechanic uses from 80 to 100. Approximately 200 are required in Michigan Bell machine switching maintenance work alone.

Did You Know That

"Jazz" is the name by which the carrier current in multiplex systems is known to L. D. test board men?

Bell system estimates saving from preserving poles and cross arms at $25,000,000.

SLACK IN DROP WIRES FOR MAINTENANCE PURPOSES

One of the difficulties of doing a neat job where a number of twisted pair drops terminate on a cable pole is the making of provision of the slack necessary so that changes may be made and that the drop wire will not be too short if the end is broken when the line is opened for testing. The "mule's ear" dead-end tie is one of the best methods of leaving this slack. The accompanying illustrations published through the courtesy of Bell Telephone News shows the method of making the tie and the appearance of a number of drops made up with this type of tie on a guard arm at a cable terminal pole.

Note Appearance of Drops Properly Made Up.

Illinois has about 3,500,000 miles of telephone wire.

Wires' Part in Railway Field

Pennsylvania System Authority Tells of Employment of Electrical Communication Methods in Railroad Operation—Details Work of Telephones—Radio's Limitations

By I. C. FORSHEE,
Associate A. I. E. E.

The object of this paper is to show the part played by the different means of electrical communication in operating a large railroad system. The telegraph, which was the original and sole means of handling communications requiring immediate attention, has given way largely to the telephone and the printer. The development of the selector was essential to the general use of the telephone for train operation and message work, the train wire being considered the most important circuit in railroad operation.

Extensive and special facilities are required in some instances to provide necessary telephone communication with the public. This includes telephones on certain limited trains in terminals.

The telautograph is important but limited to local service in terminals and junction points.

Some problems in engineering, construction, maintenance and operation as with the commercial telegraph and telephone companies, except that smoke conditions are worse along the railroad and continuity of service is possibly more important.

Radio has possibilities as a means of providing information and entertainment to passengers on trains and in the operation of freight trains and tug boats.

In handling train orders the train conductor must verify the instructions or orders he receives. The quality and accuracy of radio reception when a train runs through rock cuts, over or under certain types of steel bridges, through tunnels and during certain weather conditions prevents this means of communication from being used at this time for handling train orders.

The volume of communication traffic is affected by the seasons, holidays and emergencies.

The size of the communication system on some railroads compares favorably with that of some of the large commercial telegraph and telephone companies.

An ideal communication system would provide accurate information between any two points on a railroad system or between the public and the railroad company without delay and under all operating conditions.

*Presented at the St. Louis, Mo., Convention of the A. I. E. E.

The means of communication which will be referred to in this paper includes the telegraph, telephone, telautograph, telegraph printers and radio.

The signal system used in connection with the movement of trains, which includes the various hand operated or manual signals, and automatic signals of the different types such as semaphores, colored lights and position lights, as well as train control systems, in reality form an important part of a railroad communication system, as they convey information to the enginemen or trainmen regarding the condition of the track ahead This will not be included in the present paper.

Telegraph

Train Operation. The handling of train orders by telegraph was started in 1850 and was used more or less extensively on all the railroads throughout the country until the advent of the telephone.

Telegraph Development. The earliest installations of the telegraph made use of the simple Morse circuit; the later developments provided duplex and quadruplex operation which were quite generally used for message service, especially between terminal or relay points. It might be said that the development of the telegraph as a means of communication progressed in step with the development of the railroads themselves. The importance of rapid and accurate communication was greatly increased by the increase in mileage of the railroads the efficient management of which required prompt, accurate and complete information regarding many matters pertaining to operation and management. The telegraph is still used by some roads for dispatching their trains and handling the regular message business, although the telephone has rapidly replaced it for this class of service in many sections.

Telegraph as By-Product. Although on some railroads and some divisions of the railroads the telegraph has given way almost completely to the telephone for all classes of local service, yet it is probable that for many years to come the telegraph will still be used as a by-product of the wire plant for message service between the general office and division headquarters; also between the different relay points on the systems. This telegraph service will not be handled over direct Morse wires, but rather be a by-product obtained by compositing the telephone trunk circuits between these same points. This would mean that two pairs of telephone wires which are properly transposed can be phantomed and composited and thus furnish three telephone and four duplex telegraph circuits, all of which may be operated simultaneously without interference of one with the other. These composited circuits may be equipped with telegraph repeaters for through telegraph message business over the long circuits of, say, 300 miles or more.

Commercial Telegraph Service. For the benefit of the public, commercial telegraph offices are provided at the terminals and larger stations, and messages are handled by the railroad operators at other points.

Arrangements are in effect at many important points on some railroads for the uniformed messengers of the commercial telegraph companies to pass through the trains and collect telegrams from the passengers. Messages are delivered to passengers enroute by sending them in care of the conductor of the train (indicating by train number) on which the passenger is traveling. They are then delivered at the next point at which the train stops.

Telegraph Printers

The telegraph printer has been developed to the point where it is being used very largely between division headquarters or relay points or where there is a sufficient volume of traffic to warrant their installation, and these same composite circuits referred to above can be used for duplex operation of these machines.

Reports. For the efficient handling of freight and passenger business on a large system, it is necessary for those in charge to have current reports on the supply and demand of cars and the movement of the different classes of freight and engines; also on shop conditions where the different classes of repairs are made. This necessitates the use of many different report forms, for years handled by the Morse operators. An intelligent study of this condition would make it possible to redesign many of these forms so that they might be used in printer operation.

Type of Printer. It is believed that the

page printer using tape transmission is, in general, most satisfactory for railroad message work between the more important points. Several carbon copies of the messages or reports can be made when this is necessary and very little instruction is required to teach one to manipulate a printer if the employe is able to operate a typewriter accurately. When line interruptions occur, the perforator operator can continue to punch the transmitting tape, and as soon as the line is restored the tape can be run through the transmitter at maximum line speed with minimum of delay.

Maintenance. The maintenance of printers requires the services of a skilled mechanic, so that the more printers there are in service at a given point the less the cost of maintenance per unit, as one mechanician can take care of a number of printers.

Telegraph Replaced Largely by Telephone

The disadvantage in using the telephone in train dispatching in the early stages of its development was caused by the difficulty in signaling the desired party, as it was necessary to use code calls and this was very objectionable on heavy lines. There were many misgivings and doubts regarding the ability of the dispatcher and operators to handle train orders accurately by the telephone, and it was only after quite extensive use on certain limited installations that the telephone proved to be quite equal to the telegraph so far as accuracy and speed were concerned.

The more general use of the telephone for train dispatching was dependent upon the development and perfection of a selective calling device, which would enable the dispatcher to signal any one of the many stations connected to his telephone circuit. There were a number of types and makes of selectors in the early development, but the law of the survival of the fittest worked here as well as elsewhere and the selectors at present available for this service are both rugged and accurate with relatively little maintenance trouble. They are available for circuits having as many as seventy-five or more stations, any of which can be called independently; but on a busy section of railroad they seldom exceed half this number. The approximate time required for the bell to start to ring after the dispatcher makes the call is four to six seconds.

Time Service. One important service which was formerly handled exclusively by telegraph and which is now quite generally transmitted over the telephone lines equipped with selectors is the time service from the U. S. Observatory. This transmission takes place twice a day, at noon and midnight in the Eastern time the time pieces on the railroad used in connection with train operation for reasons which are obvious must be as nearly accurate as it is possible to have them.

Telephone

So far as the public is concerned, they are interested primarily in telephone service with the railroad company to obtain information regarding such matters as arrival and departure of trains, Pullman belt, and is an important service, as all reservations, cost of transportation, arrival and departure of freight, freight rates, etc.

When it is realized that the railroads are the largest users of almost every commodity, it will be evident that there are many other classes of information in which the public are very much interested at times and in which the telephone system forms an important link.

Intercommunicating System. In some of the larger cities, the different departments of the railroad are quite widely separated on account of the quarters required and those available; but the intercommunicating telephone systems, which may be automatic, manual or semi-mechanical, make it possible to secure those best adapted for the business by the telephone service which is as prompt as if all the parties were in adjacent offices.

Private Intercommunication System. In some places where the calling rate for strictly intercommunicating service is unusually high between the different subscribers it has been found to be economical to purchase, maintain and operate a private system of the automatic type, but this means duplication of the outside plant, wiring and maintenance, and requires a second telephone where there is occasion to have service with the commercial companies. Only a careful study, considering all items involved, will give the true answer as to the economies of this.

The long distance or trunk-line circuits of the railroad company represent an appreciable investment which should be operated as efficiently as possible to secure the best returns. This means that a relatively small number of lines are given to each toll operator who is selected because of efficiency, and knowledge of the railroad organization and can be depended upon to handle the circuits to the best advantage.

Directory Listing. It is impracticable and undesirable to list in the public telephone directory all the different departments, much less all of the individuals, of a railroad organization, so that the burden of remembering each and all of the hundreds or thousands of individuals within reach of the telephones connected to such a switchboard becomes a problem of long and careful training.

The aim of the railroads, generally, is to simplify as much as possible the directory listings, so that by calling one telephone number, connections may be established with any department or individual in that vicinity.

PBX Consolidation. This is one argument in favor of the consolidation of the private branch exchanges of a railroad where there are several exchanges in a given vicinity. The cost of service through such a consolidated exchange is the deciding factor sometimes, as it

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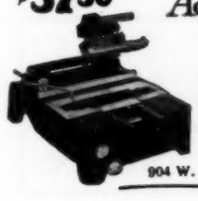

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might be necessary to lease a considerable mileage of cable circuits from the outlying points to the consolidated exchange; and if that rental and the rental of the additional facilities required at the consolidated board exceed the cost of the service through the individual exchanges, then the only remaining arguments are the twenty-four hour service and the greater convenience to the public from the simplified listing.

The advent of the automatic or machine-switching system it is believed will solve many of these problems, as the small automatic unit, called a satellite, can be used for the intercommunicating service at the points separated from the main exchange and connected with the railroad main *PBX* by automatic trunks. The calls to and from the city central offices then would be routed through the main *PBX*. The railroad operator would complete the incoming calls either by dialing the party, if on a satellite exchange, or by a cord and plug in the multiple if connected on the same switchboard. The outgoing calls would either be dialed direct by the different railroad subscribers or handled by the operator as desired by the railroad company.

PBX Traffic. During the busy hour it is not uncommon for an operator handling calls incoming from city to make 200 connections, and a considerably higher number of intercommunicating calls when made by number. The former class of calls probably will continue on a manual basis even after the central office and the private branch exchange are operating on a machine-switching basis. Through some of the larger private branch exchanges they handle as many as 18,000 to 20,000 or more calls per day.

Train Dispatcher's Equipment. There may be several dispatchers' circuits on a busy division, each dispatcher handling the movements over a given section with possibly a Chief Dispatcher's circuit operating over the entire length of the division and connecting to certain transfer points and with the dispatcher's office on one or more of the adjoining divisions. On these circuits equipped with selectors the dispatcher has control of the entire circuit; that is, the different way stations are signaled only by the dispatcher who is, in general, connected across the circuit continuously with his receiver, which may be of the head band type or a loud speaker.

For a long time the head-band receiver, used by the dispatcher, was the only type of reliable receiver available. It was very objectionable, however, especially in warm weather, during lightning storms, or where the circuit was exposed to the effects of induction from power circuits. This trouble has been largely overcome by the development of the loud speaker which, at present, is very satisfactory for this service. The loud speaker can be so adjusted that, even though there are several of them in an office, a very satisfactory operation is obtained. This is convenient also for the supervisory forces in case of emergency, as they can get all details first-hand without disturbing the dispatcher.

Selector Message Circuits. Telephone circuits equipped with selectors also are used quite extensively for handling telegraph messages, especially between local division points.

To prevent errors in the transmission of words and numbers that might be misunderstood, a special code has been developed and is in very general use. The service is faster than the Morse and very little special training is required for such operation.

The installation of telephone selector equipment for train dispatching and message service generally has been objected to by those who are accustomed to handling this business by Morse, but it also has been quite general that these same objectors are the most enthusiastic proponents of the telephone system after they have become accustomed to this operation.

Block Circuits. Interlocking plants are located at regular intervals along the railroad, permitting the crossing over of trains from one track to another on a system having two or more tracks, and also allowing the trains to take a passing siding on single track operation. These points are known as interlocking stations.

Where interlocking stations are several miles apart, intermediate stations are often established for the purpose of shortening the block between the interlocking stations. They are known as block stations.

The attendant in charge of the interlocking or block stations may be a telegraph or telephone operator and must manipulate the levers controlling the signals or switches. He is now quite generally known as a "signalman."

A "block," as used in this paper, is the length of track between block and interlocking stations where the movement over the track is governed by fixed signals.

Telephone circuits between these block and interlocking stations are known as block circuits and are used for spacing trains and for transmitting intelligence regarding arrival and departure of trains in the different blocks. They are considered next in importance to the dispatcher's circuit so far as train operation is concerned.

Telephones in shelter boxes or booths are usually located at the different sidings and signal bridges and connected to the adjacent block or interlocking stations, or, in some cases, to the dispatcher's line.

These block circuits are often simplexed and the simplex carried through for a division telegraph circuit.

Work and Wreck Train Equipment. The work trains and wreck trains are quite generally equipped with portable telephones which may be connected to the

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adjacent block and interlocking stations or to the dispatcher's telephone circuit, to keep him advised of their whereabouts; also as to condition of track or equipment on which they may be working. Before the advent of the telephone for this service, it was necessary to establish a local telegraph office and an operator was required with the work-train or wreck-train crew to transmit the necessary information to and from the dispatcher.

First-hand information can now be obtained direct from the one in charge of the train crew in less time and more satisfactorily than was possible with the telegraph.

Siding and Signal Bridge Telephones. On some roads it is the practice to establish telephone service at each signal bridge and siding. This telephone is connected to the adjacent interlocking or block station. In some cases provision is made for connection to an adjacent private branch exchange in case of emergency, so that the calling party may be connected either directly to the signal man, to the dispatcher or other individual depending upon conditions. These telephones are usually installed in shelter boxes or booths to protect them and the user from the weather. Automatic switches are used to disconnect the telephone from the line when the telephone is not in use. These shelter boxes or booths usually are provided with regular switch locks to prevent the use of the telephone by unauthorized persons.

This general scheme of installing telephones along the railroad right-of-way, especially on a busy section, is considered more favorably than the use of portable telephones as they are available for all the different employes of the railroad system in that district, and less apt to develop trouble than the portable sets. They are also inspected more regularly by the maintainers.

Emergency Circuits. In some cases an extra circuit is provided in the shelter boxes or booths. This is termed an emergency circuit and is available for service with an emergency or portable telephone carried by the work or wreck-train crews, so that it does not interfere with the operation of the regular signal bridge or way-station telephone circuit. The emergency circuit is associated with the adjacent block and interlocking stations and so arranged that it could be connected to the dispatcher or to a private branch exchange in the event of an emergency.

Portable Telephones. The renewing of ties and rail, together with other work on the track incident to track maintenance, requires that a track gang should be in constant communication with the train dispatcher, so that there will be as little delay to train movement as possible. The use of the portable telephone is essential in this operation and it also improves the efficiency of the track forces by a reduction in their lost time.

Loud Speakers at Terminals. In a busy terminal where there are crossovers, interlocking equipment, etc., it is desirable for each of the signalmen at different stations to know of all of the train movements arranged by the dispatcher in that district. This was handled by Morse for many years, but when the train and engine movements increased so much it became a great strain on the signalman. The head telephone with a long cord required to permit the signalman to handle the different switch levers, is impracticable so that more recently the loud speaking telephone has been used quite generally to solve this problem, and it is working very satisfactorily.

Observation Cars. Observation cars on certain limited trains are provided with desk telephones which are in turn connected to the railroad private branch exchanges thence to the city central offices when the trains are at the different terminals. This service, connected through to any point in the Bell System, is available for the passengers on the train up to the leaving time. The stenographer on these trains arranges for this service as desired.

Crew Calling. At some of the important division points the home of the conductors, brakemen, engineers and firemen are quite widely separated from the division office. Due to different emergencies which may arise, the variation in the amount of traffic requiring different numbers of crews, sickness and other causes, it is quite a problem to make available the necessary men qualified to handle the different freight and passenger trains without delay. This requires either special messenger service or special telephone service. It has been found in some instances that special crew-calling telephone service, (normally used for one-way operation but in emergencies employed for two-way service), is the most efficient and economical. With this system the Crew Caller gives the Telephone Operator the list of members to be called indicating time and place to report for duty.

Public Telephones at Stations. For the convenience of the traveling public, and not directly associated with railroad operation, a relatively large number of telephones is required at many of the important terminals to enable the patrons to make local and long distance calls through the commercial telephone systems. This convenience is provided for by the attended and unattended telephone stations, the latter being the usual coin in the slot or pay station telephones.

Train Bulletins. On many roads a regular bulletin service is also in effect giv-

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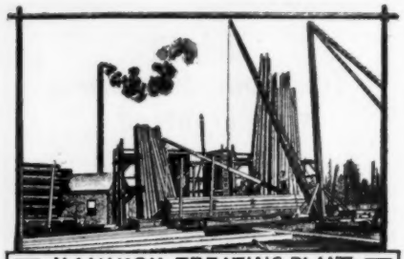
ing information of general interest to the traveling public on through limited trains. This includes stock market quotations on the principal issues, baseball scores, and any other items of major interest. These bulletins are generally posted in the club or observation cars and are received at the principal points en route.

Telautograph

The telautograph has been used quite generally for recording information regarding the make-up of trains, track assignment for trains also the time of arrival and departure of different trains in the terminals and other important division points. This is a service which is of vital importance to the baggage department and in handling mail as arrangements must be made to load baggage and mail on the trains the latest possible before train departure also for the necessary truck to unload promptly incoming baggage and mail from the trains just arriving. This service is of a local nature. The circuits may have one or more transmitters and several receivers, all of which are operated simultaneously.

(*To be continued in October issue*)

Angora, Turkey—Allmanna Telefonaktiebolaget L. M. Ericsson has received an order for a 1,000-line automatic exchange to be installed here.



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Tri-State Making Excellent Showing

St. Paul, Minn.—In his quarterly letter to stockholders, President G. W. Robinson of The Tri-State Telephone and Telegraph Co., after announcing the payment of the eighty-ninth quarterly dividend on preferred stock of the company, takes occasion to refer briefly to the showing for the current year. Earnings for the first six months increased 5.81 per cent over the corresponding period of last year, operating expenses increased 4.63 per cent, taxes have increased 14.72 per cent and net earnings after interest show an increase of 8.58 per cent. During the first six months of the year, over one-half million dollars was added to the plant account and a net gain of 5,058 stations has been made.

John L. Hosea Buys Osgood, Ind., Plant

Columbus, Ind.—John L. Hosea, owner of four telephone systems in Bartholomew county, Indiana, has bought the Osgood Telephone Company, a property with approximately 600 stations.

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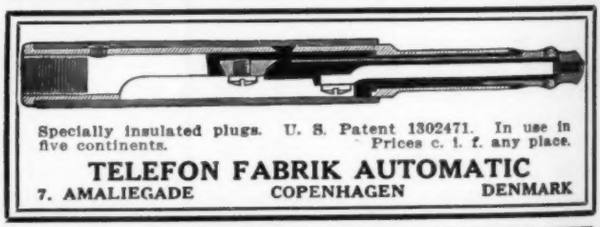
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Pay Station a Romance

"Drop a Nickel" Idea Picks Up Millions

In the annals of Yankee inventive genius one would have to dig deep to find a more interesting group than the quartette who made the nickle famous, Gray, Soby, Whitney and Long. Of the four lively and talented characters, but one, George A. Long, at present secretary and general manager of the Gray Telephone Pay Station company, survives, still as full of pep and high purposes as he was back in the eager eighties when the resonant "ting" of the first Gray pay-station rang out in a youthful telephone world.

Through all of the aggravations and vicissitudes of the pioneers' lot these four worked together to achieve for the child of their brains a popularity in the telephone industry equal only to that of breakfast, dinner and supper. They were a restless lot. The list of patents granted to them shows that "let well enough alone," was a thought alien to each and all of them. More than 80 patents have been granted to the company, the first one being granted to William Gray, August 13, 1889, and the last one of record going in the name of George A. Long, on August 29, 1924. Long's list of 38 United States patents granted gives an idea of the inventive urge of the man. Foreign governments have granted him 19 patents, and there still are applications pending abroad and at home. Honors have been conferred upon him by his own and foreign governments, and the Gray company has been given enough international exposition award medals to decorate a field marshal.

Gray had his inspiration for the pay station in 1887. He needed a telephone badly, so instead of simply reconciling himself to the prevailing condition, he set to work to remedy it. This was the way Gray worked—he'd get a flash of an idea and stay with it until it emerged in working form. The legion of baseball fans in the telephone industry will be interested to know that another one of the inventions of this versatile genius, was the inflatable chest protector. In fact, the history of the telephone pay station was closely linked with the early days of his time-honored protective device, now guarding the facades of baseball catchers and umpires.

Charles Soby, a wealthy Hartford business man and baseball magnate, became acquainted with Gray as a result of their mutual interest in baseball. It was Soby who "put in" with Gray and arranged with Amos Whitney, the manufacture of the first Gray pay station. Whitney and Gray had worked together in the Colt firearms factory, making devices that "create all men equal." Whitney had later entered into a partnership with Francis A. Pratt, forming the present famous and great machine tool company of Pratt and Whitney. Gray went with the infant Pratt and Whitney company as head of the polishing department.

In the Pratt and Whitney outfit was a bright apprentice pattern maker, a sixteen year old youngster, to whom was assigned the job of making the first working model of the Gray station. That boy was the now noted Long. From a rich background of down-east ancestry he had a rare combination of keen and stubborn qualities. He also was one of the type that caught bright ideas on the fly and stayed with them until they were made to work, like the inventive Gray. His record of production of pay station types is evidence of his amazing capacity for work. He invented the first single-slot coin collector, the first three-slot and the first portable coin collector. Then he developed the combined telephone and pay station—the compact type—2,000 of which, then especially designed, formed the Wanamaker installation in Philadelphia, the largest in the world.

Mr. Long also provided the first automatic, multi-coin prepay stations. Of these, over 60,000 are in use in New York City alone—their installation has become almost universal. As early as 1905, 50 of his prepayment machines were put to good use at Fall River, Mass., on the Strowger automatic telephone system.

Long has lived to see the business he helped establish in an unusual and enviable condition—that of being a well-liked monopoly with business and friends all over the telephone world. He has seen the winning of the strongest possible endorsement for the Gray pay station, its adoption as standard by Bell, Automatic, and other manufacturing and operating companies, and its reception as a necessity by a critical public. As a very substantial reminder of the "arrival" of the idea the four teammates launched almost forty years ago, he can let his gaze rest upon a factory of formidable proportions and continuous activity.

One of the very interesting catalogs now current in the telephone industry is that of the Gray Telephone Pay Station company, which tells in detail of the fine history of the company, as well as describes fully the many types of Gray stations now made.

The official lineup of the Gray company today consists of Alfred Spencer, Jr., president; Clarkson N. Fowler, vice president and treasurer; George A. Long, secretary and general manager, and Edward A. Hagey, assistant treasurer.

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